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TWELFTH BIENNIAL REPORT

OF THE

STATE BOARD

OF

FISH COMMISSIONERS

FROM DEC. 1, 1894, TO DEC. 1, 1896

BY AUTHORITY

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1897

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NOTE OF TRANSMITTAL.

To the Governor—The board herewith submits a history of its operations for the biennial period from November, 1894, to November 30, 1897. Herein will be found a statement covering in detail all the work of propagation and distribution of food and game fish, the improvements made at stations already established, and the new work carried forward during the time covered by the report, and the proposed new work.

Herschel Whitaker,
Horace W. Davis,
Freeman B. Dickerson,
State Board of Fish Commissioners.

"A certain man had a goose which laid him a golden egg every day. But not contented with this, which rather increased than abated his avarice, he was resolved to kill the goose and cut up her belly, that so he might come at the inexhaustible treasure which he fancied she had within her. He did so; and, to his great sorrow and disappointment, found nothing."

"They who are of such craving, impatient tempers that they cannot live contented when fortune has blessed them with a constant and continuous sufficiency, deserve to be deprived of what they have. And this has been the case of many ambitious and covetous men, who, by making an essay to grow very rich at once, have missed what they aimed at, and lost what they had before."—*Æsop's Fables.*

REPORT OF THE STATE BOARD OF FISH COMMISSIONERS FOR 1895-1896.

The board, during the period covered by this report, has been engaged in carrying forward the work heretofore established, of the artificial hatching and distribution of fish for the great lakes and inland waters of the State. The stocking of our inland streams with brook trout has been carried on to the full limit of our capacity. The results of this work, as heretofore, are full of the greatest encouragement. What has been said regarding the success of this work in former reports has been emphasized by our subsequent experience.

A better object lesson of the success of the artificial propagation and planting of brook trout is not presented anywhere in any country than in Michigan.

Douglas Houghton, the eminent scientist, and the surveyor of a great part of the wild lands of this State, said of the streams of the lower peninsula, based on personal observation and examination, that they contained no brook trout. Mr. Bela Hubbard, an associate and companion of Houghton, in his Memorials of a Half Century, makes the same statement, and they are corroborated by the early settlers, woodsmen and sportsmen.

Although the commission was organized twenty-four years ago, the first few years of its existence were given to the gaining of a knowledge of the subject of fish culture, and the marshalling of means with which to prosecute the work. Practically the work of planting our streams with brook trout did not begin until 1879. Since that time our facilities have been gradually enlarged, and the work has gone forward, steadily increasing. Now the streams of every county in the State but three, whose waters are not suited to this fish, furnish excellent trout fishing. The streams of some of our river basins, like the Pere Marquette and the Au Sable, furnish trout fishing not to be excelled in this country. In both of these streams and their tributaries may be caught brook trout, rainbow trout and grayling.

While it may be said the trout is a game fish, it must not be forgotten that they are also a source of profit to the State. Passing over the fact that the residents of the sections in which these streams are found derive from these sources fish for their own consumption, we come to the more significant value they have for the State, in bringing here the residents of other states, who leave a substantial evidence of their presence in the money paid to railroads and liverymen for transportation, and to hotels and tradesmen for board and necessaries. The money the State expends in the planting of brook trout is thus returned many times over and is a paying investment in every sense.

While this work is all necessary and falls within the province of our duty, it is of but slight significance compared with the greater work to which we have devoted our energies, the building up of our great commercial fisheries. We have now reached the point where the output from our fish hatcheries places our work of planting of commercial fish among the most effective in the country.

Our experience in artificial propagation and our knowledge of its past successes, confirm us in the opinion that this great work can be successfully carried on to a renewal of the wasted fisheries, if we can bring to our aid in this effort intelligent legislation, limiting commercial fishing operations to the capture of *mature, adult fish* only.

The object of fish culture, of fishing operations and of protective legislation, in the hands of men who consider the necessity of the preservation of the fisheries should be to follow a policy that will permit the catching and marketing of merchantable fish, and the supervision of netting, and to stop the capture of fish too young and immature to spawn and having but small market value.

To proceed on any other line than this means an ultimate destruction of our commercial fisheries, the elimination of fish as one of our common articles of food, the destruction of the fisherman's industry, from which he gains his livelihood, and makes wholly useless the efforts of the State is making to preserve the fisheries by planting. The fisherman should take counsel from his experience, and act in accordance with the conclusions that naturally follow.

The history of commercial fishing in the great lakes for the past twenty-five years *is the history of an abuse.* The people of the State are more deeply interested in the preservation of the great lake fisheries than the person who draws from them the product that gives him his daily bread. The people own the fisheries, and the public right to their maintenance is above that of the fishermen as a class. All acts exercised by the fisherman in following his business are subordinate to the public's right to have the fisheries maintained. He enjoys a *privilege* and not a *right* in netting in the public waters, and he must so conduct his operations that he will not endanger the right of the public to have the fisheries preserved for the future.

The urgent necessity for steps to prevent the further wasting away of the great lake fisheries first challenged public attention in this State about twenty-four years ago, when the inroads upon the parent stock had become manifest. At that time modern fish culture was in its infancy, but the experience of those interested in the artificial propagation of fish showed that its possibilities were great.

The State of Michigan, at this juncture, recognizing the importance of these discoveries, and the promise it gave for a renewal of her fisheries, organized a Commission of Fisheries, investing it with power and authority to artificially hatch and distribute in the public waters of the State, the choice commercial varieties of fish that had so long made these waters famous. Money was appropriated as needed and the work has been since carried on in the public interest, and not for the benefit of any class or industry.

It was believed—and there was warrant for that belief under fishing operations as then conducted—that artificial propagation alone would ultimately bring back the productiveness of the fisheries. But at that time, and for several years following, the output of the hatcheries was comparatively insignificent. Time was needed to develop the new industry and the increase of hatching operations was naturally slow.

At the outset, the task of a restoration of the fisheries after sixty years of depletion confronted the board. This had to be made good in the face of yearly increasing waste, caused by the increase in the number of fishermen's boats and nets.

Custom had sanctioned the taking and marketing of all fish the nets would take. In the east, west, and south the demand for whitefish and lake trout was increasing.

The fisherman's business became a lucrative one, large sums of money were made in a single season's operations, and the result was the natural one, the enlistment of more capital and men in the business and a large increase in the number of devices of capture.

As a result, the shoals and reefs of the entire lake system were covered with the nets of the fishermen during the spawning season, and the catch grew to be enormous. Fish became a drug on the market, and those that could not be marketed fresh were salted and sold at much lower figures than when fresh. The ease of capture and the large quantities taken made it a profitable business considering the money invested. At this time fishing was prosecuted with small sailboats and gill nets.

In 1850, or perhaps a little earlier, that most killing of all netting devices, the pound net, was first introduced into our waters. This method of fishing greatly increased the catch and still larger profits were derived from the fisheries.

About the year 1868 came the invention of the modern freezer, in which fish might be kept in a frozen condition, ready to be marketed as fresh fish during the seasons of the year when the markets were not overstocked with fish freshly caught, thus affording a new and lucrative opportunity for the investment of means in fishing.

With no limitation whatever laid on season or device for capture, fish were taken whenever and wherever they could be found. Schools of fish were pursued for miles by the gill netters; the spawning reefs were covered with nets during November and December when the fish came on to spawn, and countless numbers of milting males and females, ready to spawn, were taken heavy with ova and milt and killed before performing the act that would add to the stock with which the lakes were to be renewed.

As time went on the havoc began to manifest itself. Localities that once produced large quantities of fish began to decline in yield, and finally became unproductive. The constant pursuit of the fisheries naturally resulted in the extermination in a great measure of the large and merchantable fish. But the fishermen had invested large sums of money in the enterprise and the diminution of the catch to the point where it ceased to pay and where losses of investment threatened, led them to change their methods of capture, to still make the business profitable.

Then came the first step in the contraction of the meshes of the nets for the capture of small fish. Up to this time nets with meshes of five and six inches in extension had served all purposes, and took nothing but large fish, and this diminution of size of mesh has contributed in a large measure to the present unprofitable condition of many of our fisheries, and threatens their absolute extinction.

A single illustration of this diminution of size of mesh and its gradual progress was brought to our attention during the past summer, by one who has long been familiar with the lake fisheries, and is a fair example of the history of the gradual diminishing size of the meshes of the nets in the great lake system in the past few years.

The locality referred to is the east shore of Lake Michigan, but it can be said that what is true in this respect of this locality applies with equal force to our entire lake coast. The information here given was derived from a reliable source and can be authenticated beyond a doubt.

The meshes had been contracted considerably before the year 1870. In 1870 the size of mesh of gill nets fished on that shore was $4\frac{1}{4}$ inches, and down to the past season has been reduced in this ratio, from $4\frac{1}{4}$ to $4\frac{1}{8}$ inches, 4, $3\frac{7}{8}$, $3\frac{1}{2}$, $3\frac{1}{4}$, $3\frac{1}{8}$, 3, $2\frac{7}{8}$, $2\frac{3}{4}$, $2\frac{5}{8}$, $2\frac{1}{2}$, $2\frac{3}{8}$, and now the size of mesh is $2\frac{1}{4}$ inches.

It is not generally understood what is meant in speaking of the size of meshes of nets. The measurement of all meshes means the length of mesh when it is stretched to its utmost extension. The same mesh, when opened, as used in fishing, is very much smaller than is generally thought. The idea commonly accepted is that size as applied to a mesh means the size of the opening as fished, but this is not the fact. A three inch mesh does not mean a net that has a three inch opening.

Herewith are given a number of illustrations, showing the sizes of meshes of nets, beginning with a six inch mesh, closed, as they are usually measured, and meaning its entire length when so closed. Following this will be found the same mesh shown opened as fished, and other illustrations showing different sizes of meshes:

**A*. Six-inch pound net mesh, as measured, and the same as used in fishing.
**B*. Five-inch pound net mesh, as measured, and the same as used in fishing.
C. Four and one-quarter-inch gill net mesh, as measured, and the same as used in fishing.
D. Three and one-half-inch pound net mesh, as measured, and the same as used in fishing.
E. Two and three-quarter-inch gill net mesh, as measured, and the same as used in fishing.
F. Two and one-half-inch gill net mesh, as measured, and the same as used in fishing.
G. Two and one-quarter-inch pound net mesh, as measured, and the same as used in fishing.
H. Two-inch pound net mesh, as measured, and the same as used in fishing.

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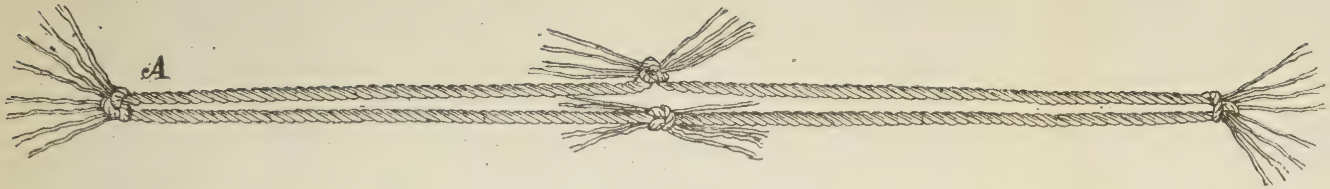
* Neither of these sizes are now much used.



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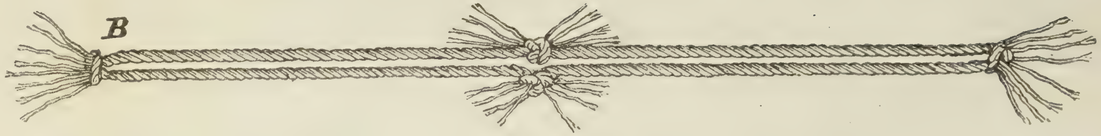

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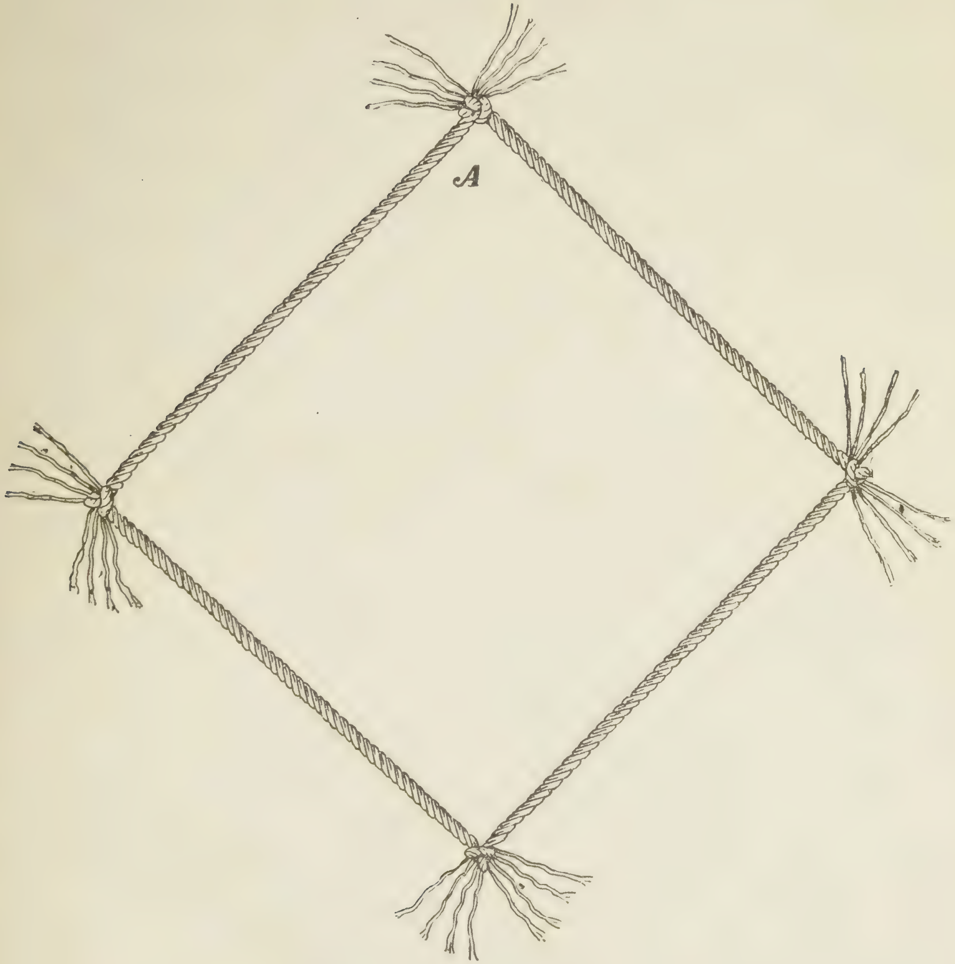

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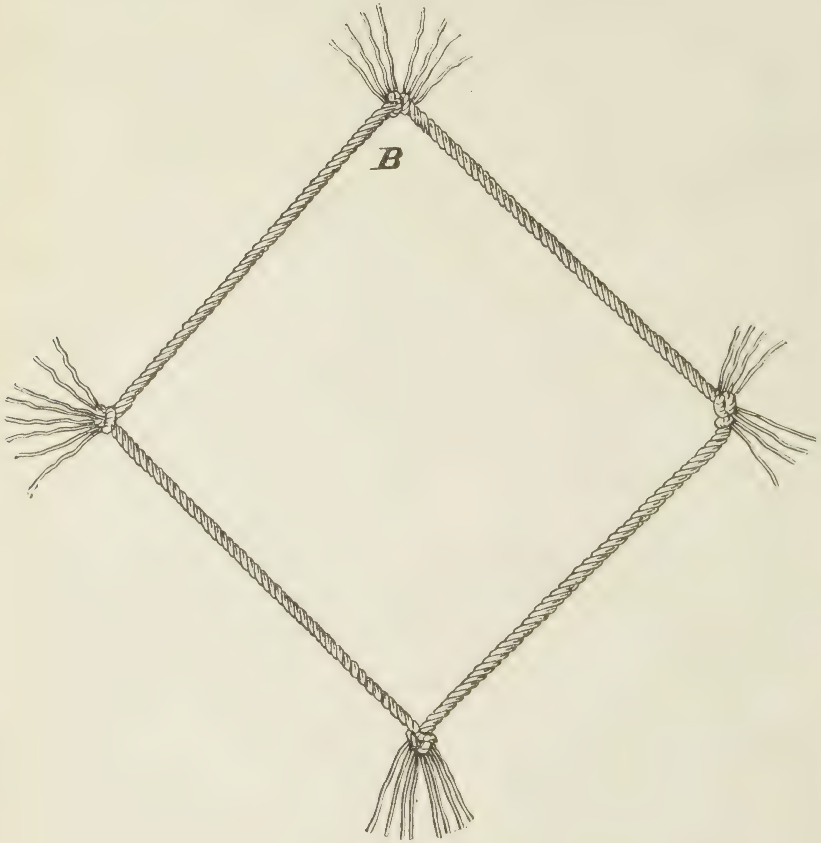

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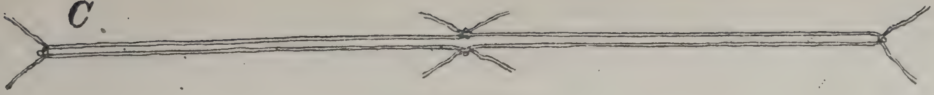

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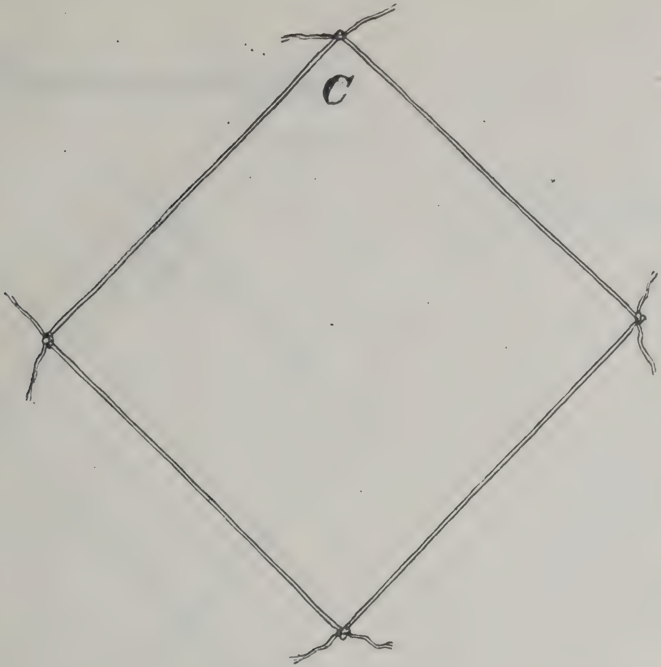

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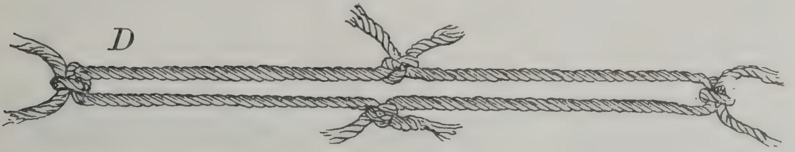

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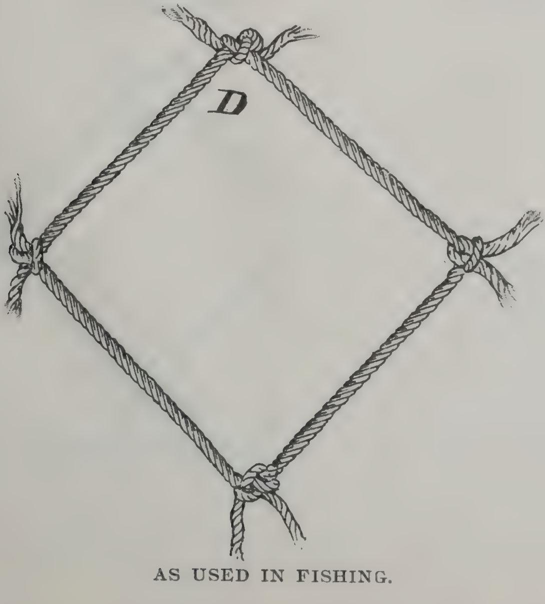

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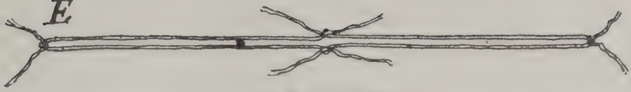

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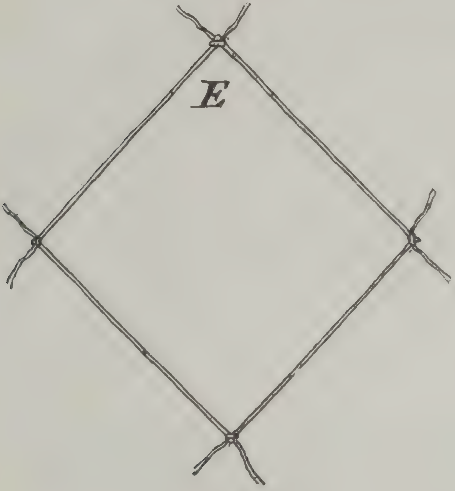

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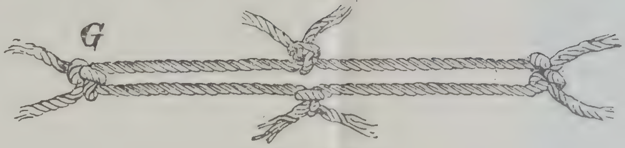

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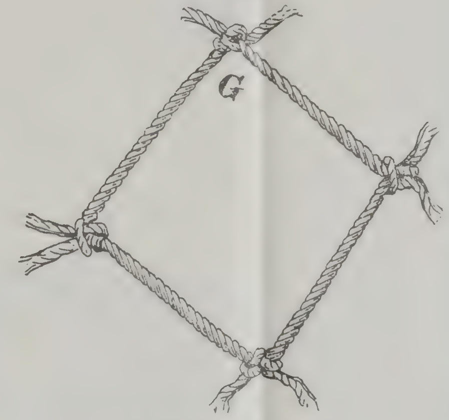

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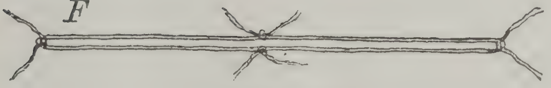

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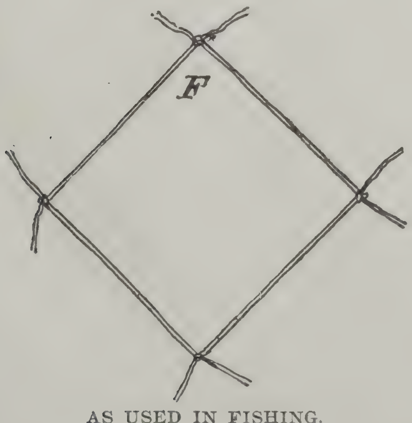

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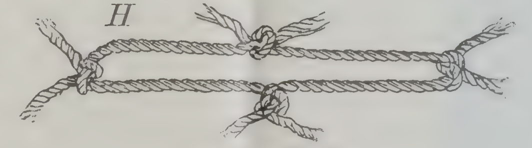

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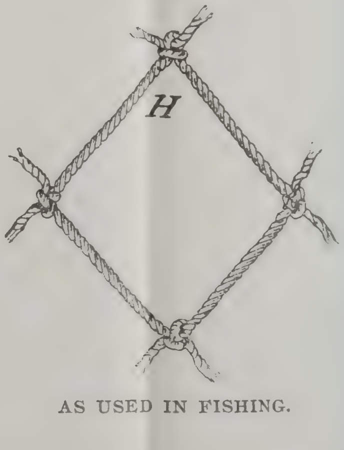

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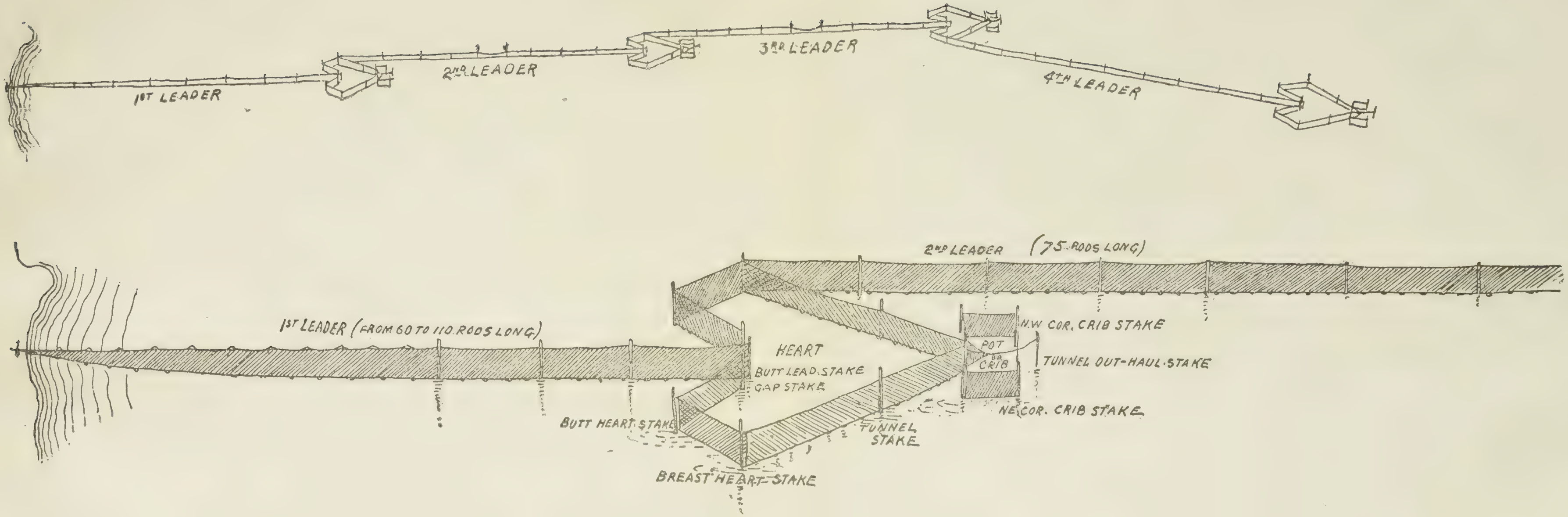


DIAGRAM SHOWING OPERATION OF POUND NET.

Commencing with the middle or latter part of October, the gravid females and milting males of the whitefish and salmon trout, with unerring instinct turn from the summer feeding grounds, to the shoaler water where gravelly reef or rocky bottom offer tempting places of resort for the performance of the reproductive act. To these places they swarm in large numbers and remain engaged in spawning until as late as the 10th of December, in certain localities, although the month of November covers the principal spawning period of the whitefish, and the last half of October and the month of November the spawning season of the salmon trout. These spawning reefs are known not only to the fish, *but also to the fishermen*, who there meet them with every device of capture. Comparatively few fish are able to reach the spawning beds unmolested by nets, and the most profitable season of the year is then realized by the fishermen.

When the ice and storms of winter make fishing impossible or uncertain, fishing is abandoned, and January and February and a part of March may be said to be the only season of the year when fishermen and nets are idle and the fish are not pursued and taken, although in Lake Michigan and Saginaw Bay it is pursued almost continuously.

It must be borne in mind that the destruction of the fisheries is but in small measure represented by the number of parent fish thus taken upon the spawning beds. A great menace to the fisheries is the destruction of the immense quantities of ova that are lost by killing the fish before spawning, which, if left unmolested during the month of November would contribute largely to the increase of their species.

As soon as the spring season permits, the active operations of fishing are again begun. The pound nets are set and the gill nets begin their work.

The pound net is a trap device, in which the fish are preserved alive when taken, and it therein differs from the gill net, in which the fish are usually killed.

The pound net is set approximately at right angles with the shore and consists of the "lead," which is the fishing part of the device, the "heart" and the "pocket" or "pound."

In operation this device presents the following appearance:

In principle the net operates after this manner: The fish in passing up and down the shore are suddenly confronted by the "lead" of the net, which is usually of large mesh, presenting a bar to their progress, and serving simply to turn them from their course. When thus turned, they seek the deeper water and not the shore or shallower end of the lead; thence they work along the lead until they pass into the heart, and from thence into the pocket or pound. As before stated, this net is most destructive because it takes everything.

At stated intervals the net is visited, the lines securing the corners of the front side of the pound are released from the stakes which hold them, and the front and sides are lifted and carried toward the back of the net, and as soon as the net is sufficiently raised, the fish are scooped out with a hand net into the boat and the net is re-set. The meshes of the pocket, or pound, should be made sufficiently large to allow the escape of the small fish.

Pound nets are usually set in strings, the lead of the second net beginning at the rear or back of the pound of the first, the lead of the third beginning at the back of the pocket of the second, and so on. In localities where shoals are extensive, for instance in Saginaw Bay, and on the north shore of Lake Michigan, these nets have been set in strings of as high as *twenty-five.* The average length of leads is from 75 to 80 rods. It will be seen that this net is a most formidable engine of destruction. In addition it must be understood that these nets, in practice, are set in strings as long as the fisherman chooses and finds profitable, and the strings as closely together up and down a shore as his desire may incline him.

Gill nets are largely used and in this device the fish are caught by gilling, *i. e.*, in attempting to pass through the net the gills of the fish become enmeshed in the twine and they soon die.

As the fish diminished in size by constant fishing, the meshes of the nets were ordered made smaller. Legislation should require the meshes of the nets to be enlarged, thus permitting the escape of the small and immature fish.

All fish marketed are classified by the wholesale buyers into three grades, and the grades thus established govern the grading of commercial fish on the great lakes in this State and are known as the Chicago inspection rules.

These rules were established soon after the catch of small fish began to be important in quantity, *and were made to protect the large dealer, not to protect the small fish from capture.* The presence of any considerable quantity of small fish thrown on the market, mixed with larger fish, resulted in loss to the buyer, as he was paying only for merchantable sized fish, while he was getting, in fact, a large proportion of small ones, that, under the demands of the trade, had to be culled. The undersized fish are worth but a small price compared with the larger fish. Thus, in order to *protect himself* the wholesaler established this system of inspection. *It did not, nor was it intended to, stop the taking of small fish,* but it served the commercial end, by separating the large from the small fish, which are worth but a bagatelle compared with what their value would be if left in the water for two more seasons.

It is a just criticism of such methods to say that a business that calls for any such commercial regulation has fallen into a condition where the strong arm of the law should intervene to correct an abuse that is manifest on its face, or the State must sit supinely by and see her fisheries which are a source of wealth and of cheap food to her people, absolutely wiped out.

The following are the Chicago inspection rules:

"Standard No. 1 whitefish, shall consist of sound whitefish, well cleaned, trimmed, with head off, split on the back, free from rust or ragged, weighing not less than one and one quarter pounds each, not measuring less than twelve inches, measured from extreme scale on tail to extreme scale on neck.

"Standard No. 2 whitefish, shall consist of sound whitefish, well cleaned, trimmed, with head off, split on the back, free from rust or ragged, weighing not less than *three-quarters of a pound each,* not measuring less than ten inches, measured from extreme scale on tail to extreme scale on neck.

"Standard No. 3 whitefish, shall consist of sound whitefish, well cleaned, with head off, split on the back, smooth on the face, free from rust or ragged, *weighing less than three-quarters of a pound.*

"Standard No. 1 trout, shall consist of sound fish, weighing not less than two pounds, well cleaned, trimmed, with head off, skull bone out, split on the back, free from rust or ragged.

"Standard No. 2 trout, shall consist of sound fish, weighing less than two pounds, well cleaned, trimmed, with head off, skull bone out, split on the back, free from rust or ragged."

Having spoken of the character and varieties of nets that are most largely used in the great lake fisheries, we will now proceed to a consideration of the number and the length of these devices fished in the great lakes within the jurisdiction of this State alone, as they are the only ones with which we are directly concerned.

The coast Michigan possesses bordering the lakes is very close to 2,000 miles, following the indentations of coast and bays. For a better understanding of the application of the fishing devices to the water, it may be well to state that the fish under natural conditions are not distributed equally in all parts of the lakes. Certain portions of the lakes are known to be "feeding grounds," where the fish are found at certain seasons, and they pass from these places during the month of November to other places where their spawning grounds are found.

In considering the number and extent of fishing devices it may be said that in practical fishing operations the nets are not spread over the entire waters of the lakes, but are grouped in certain localities where the fishing grounds exist. With this understanding, a better comprehension may be had of the immense destruction that can be wrought with the large number of nets now fished in our waters.

The statistics of the fisheries of this State for the year 1895, carefully taken under the direction of this board, show that there were 22,201 gill nets fished whose length was 2,380,014 fathoms, or *2,740 statute miles.*

That there were 1,588 pound nets, the length of the leads of the same being 226,772 fathoms, or *257 statute miles.*

That there were 636 seines and fyke nets, measuring in length 34,789 fathoms, or *39 statute miles.*

Making a total length of nets fished in Michigan waters alone *3,036 statute miles.*

As an object lesson in this connection that will be better understood, these nets, if set end to end, *would cover our entire lake coast one and a half times*; or, if stretched from Detroit westward, would reach to San Francisco and extend into the Pacific *five hundred miles.* It is a marvel under this condition of things that any fish escape. The foregoing facts concerning the fisheries and methods of fishing show the influences that have been at work since the discovery of the Northwest in accomplishing the great waste of the parent stock.

For the last fifteen years repeated attempts have been made by the commission to secure a regulation of the fisheries by the enactment of laws to prevent the taking of whitefish and trout during the spawning season, and to enlarge the meshes of the nets to permit the escape of small fish. All attempts to pass such legislation have thus far failed, because of the ability of the fishermen to influence the legislature against it. It is another instance of the power of vested capital in a fight against public interest when the public itself takes no personal interest in the matter. Nothing but the arousing of public spirit in the legislature, to the necessity of the preservation of the fisheries, will save them from early destruction. The fishermen are enjoying the benefits of the bounty of the State in restocking the waters, without cost to them. In other words, and in plain language, what the fishermen desire is to be the chief beneficiaries of the fisheries, and their attitude has been one of continual opposition to any attempt to prevent a waste and destruction of the fisheries. They wish to take everything that comes to their nets regardless of the people's rights to have good fishing maintained. They believe in the principle: "After me the Deluge."

There has been an entire change in the methods of the fisheries within a few years. There was a time when the fisherman, the man directly interested in the catching of fish and in the money to be made from the business, was the man most deeply interested in the pursuit. With the decay of the fisheries came changed conditions. Times began to be hard for the fisherman. He had no money to invest in new twine. Then came the man of capital who had money to loan, who was making money in the wholesale-way out of the fishing industry. This man never fished for himself. He stayed ashore. He never endured the hardships of the calling. His interest in the fisheries began and ended with the profits that might be made by buying and marketing fish. His hands were not roughened by exposure. He did not participate in the personal hazards of the calling of the fisherman. As a rule, he had no personal knowledge of the details of the handling of nets, and such information as he possessed was wholly theoretical, yet, before committees, whose business led them to investigate these abuses, his voice has ever been loudest in defense of the "perils and hardships of his calling!" although his sufferings were all vicarious.

He offered to furnish the small fisherman with nets and trust him for his pay. Like all offers of the kind, the fisherman found it easier to get into debt than to get out, and in fact they seldom are out of debt to the men who furnish them with nets and control the price of fish in the only market open to him; the steamer of the buyer that visits the fisheries on stated days and takes his fish. As the fishing industry on the lakes now stands, the substantial profit is gathered from them by the man of large means, who is often a non-resident and is thus able to retain the small fisherman in a semi-serfdom or vassalage.

The statistics of the catch of whitefish in Michigan waters in 1895 shows that there were 3,142,170 pounds of whitefish caught and marketed; 2,134,170 pounds were No. 1, and 1,008,000 pounds were No. 2 and under. Baldly stated, this means that one-quarter of the catch were fish classified as No. 2's and under, which sold for about 2c per pound. If these fish had been permitted to remain in the lakes for another year, the increase in value, weight and price considered, would have been one-third greater. But the price is of small significance when we think of the serious results that follow such senseless methods. No fish should be put upon the market except such fish as have a good merchantable value, and the young and immature fish should be excluded from the catch.

The significance of present conditions will be more apparent when it is appreciated that a whitefish does not spawn before she has attained a weight of at least two pounds, and that the taking and marketing of any female fish under that weight means that there has been eliminated from the supply not only a fish that has never contributed anything to sustain the stock, but it has resulted in placing on the market a fish of little commercial value. One year more and she would have gained largely in weight, and if permitted to pass beyond the spawning season, would have added her quota of embryos to the perpetuation of her species.

Evidence might be multiplied of the wholesale destruction of small whitefish and salmon trout in our waters. One or two incidents of recent occurrence, however, must suffice. This season, a wholesale fish dealer in Detroit received from a Grand Haven firm a barrel of small whitefish, about the size of a pork barrel. Notice was given to the commission of the arrival of the shipment, and we were invited to inspect and examine them. At a low estimate the barrel contained between twenty-five hundred and three thousand whitefish. The shipper notified the consignee that *he could supply him with a like quantity and kind every day during the season.* The offender with others was arrested and their nets found to be under the legal size of mesh, although the size prescribed was *only 2¾ inches.* Nets to the value of $25,000 were seized in this one locality, and it is a notorious fact that the fishermen all over the lakes are with few exceptions operating with like illegal nets.

The plea of these fishermen was an ignorance of the law, although their attention was called to the illegal size of the mesh when the nets were ordered, and they persisted in ordering them under the statutory size. The hollowness of this claim is apparent.

In considering the question of what is necessary to re-stock the lakes with the whitefish, let us look at the great task confronting the board. In the first place, unrestricted fishing operations, as to season or quantity or size of fish taken, have been carried on uninterruptedly for years. The parent stock and its power to sustain itself has been impaired by the killing of immature female fish that have never spawned, the adult fish have been caught in immense numbers on their spawning beds before casting their ova, and the fish artificially hatched and distributed have been caught and marketed before coming to a marketable size.

To correct this, intelligent laws should be passed and *enforced*, permitting the taking of adult fish, and leaving the smaller ones to come to maturity. Opportunity should be afforded the gravid fish to spawn unmolested. If this be done, with the large output of artificially hatched fish now being put in the lakes, we know that the waters of our State will in a few years again teem with the whitefish and salmon trout. The food of the young and of the adult fish is as plentiful now as it ever has been, and if by the enactment and enforcement of just laws we throw the protection about the fisheries they need, and which the commonest intelligence must see is necessary for their preservation, we shall have ever ready at hand a wholesome food, abundant in quantity, cheap in price, that has grown to maturity, without cost or care.

Objection has always been raised by the opponents of the regulation of the fisheries, that we should secure co-operation from adjoining states and secure a uniformity of statute in all. The fallacy of this argument, so far as our own fisheries are concerned, is apparent. But if we admit that as the argument, would it not be an equally bad policy for the State to attempt to stamp out epidemic diseases, unless adjoining states would agree to take similar action? Facts show that Michigan has more value in her fisheries than any other adjoining state, and under such conditions the first duty of the State is to attend to its own material interests. It is no argument to say that because another state is willing to see its valuable fisheries carelessly wasted, that policy is good for Michigan.

The nonsense of this argument is also apparent, when we consider that the country lying opposite our border, having an extent of territory on the Great Lakes far exceeding that of our own and adjoining states, long since awakened to the necessity of conserving her fisheries. Without taking advice from her neighbors or awaiting their action she went sturdily, forcefully and promptly to work to enact regulations which have resulted in preserving her waters to a point where her fisheries are more profitable than our own. We refer to the Dominion of Canada, whose fisheries have been watched over and cared for by men keenly alive to their importance and the necessity for their preservation. Her territory is opposed to our own on our entire eastern coast and to the greater part of our Lake Superior coast.

The extent of our coast adjoining Ohio is small, but that state has passed more laws for the protection of her fisheries than our own and so has Minnesota. Wisconsin has but a small amount of border compared with ours and her fisheries are insignificent in extent or value with Michigan's.

Illinois has ceased to be a fish producing state. So has Indiana, which has but a fragment of frontage on the great lakes. Both of these states have permitted their fisheries to be destroyed without an effort to prevent it. So there can be no expectation they will take action in this regard.

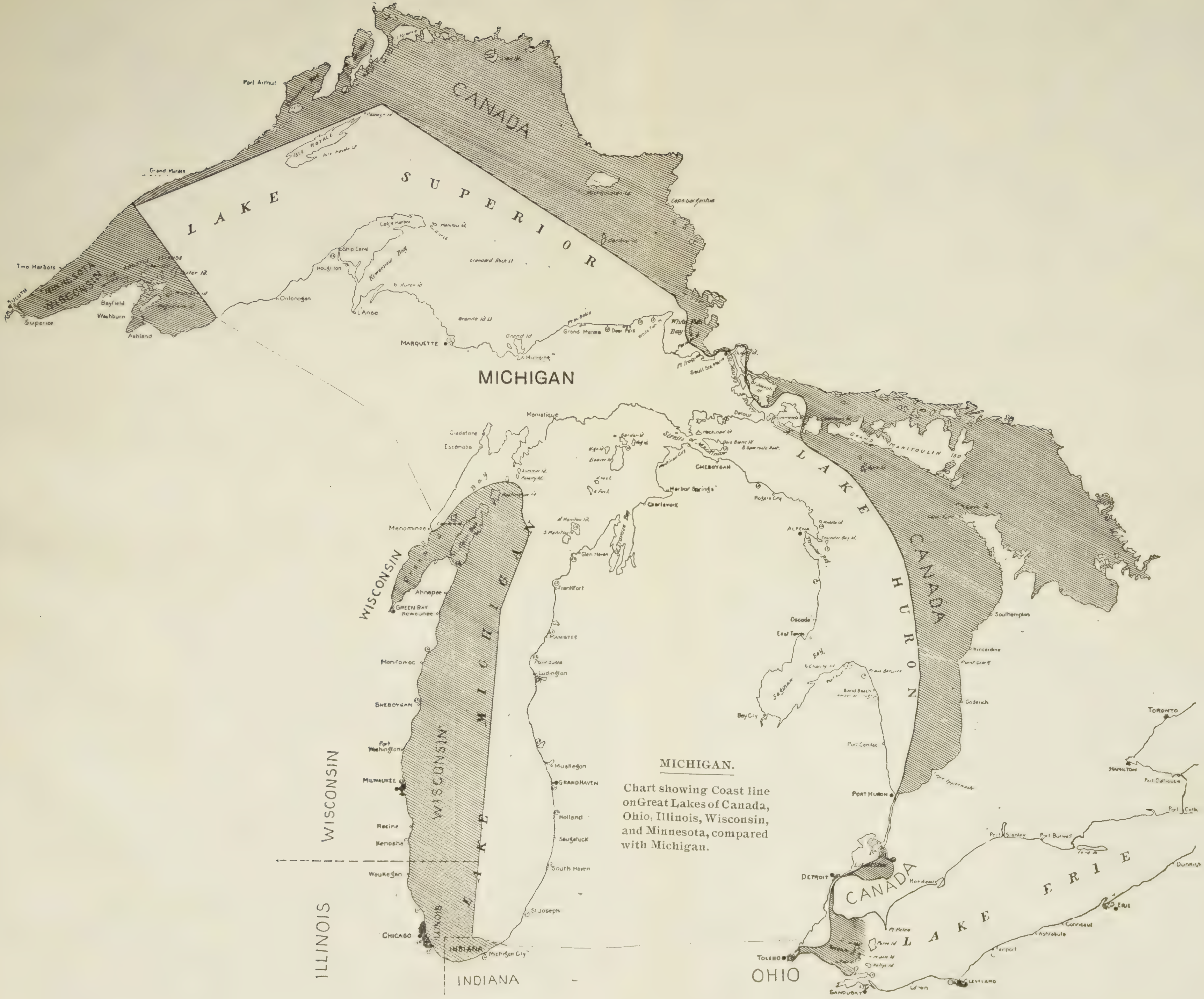
Canada protects her fish by the imposition of a close season for all the lakes, of the month of November, which is the great spawning month of the whitefish and salmon trout. She also prescribes the number of pounds that may be set in a string, the number of strings in a locality, the size of the mesh, the distance nets shall be set from shore, and the manner in which they may be set in channels. She also imposes a license upon nets and boats, and in other respects exercises a complete control over an industry she appreciates to be of great material value.

A glance at the map herewith submitted will show that if there were anything in the argument, that we should wait on our neighbor, we need no longer wait, for our greatest neighbor and the one most interested in the fisheries long ago took the necessary steps to protect herself.

Canada, next to Michigan, is the largest breeder and planter of commercial fish in the lakes, so whatever advantage she may derive from our work is, in a large measure, realized by us from her enterprise in this respect.

Given an equal area of land and water, the area of water can be made to produce the larger quantity of food. And so far as the effort of man is concerned in the production of these areas, the advantage is largely in favor of the water.

Man fertilizes the soil, prepares it for the seed, sows his crop, tills and watches it almost continuously until the harvest. Man sows his seed in the waters, but he neither tills nor watches the sowing. The food upon which young fish live and thrive is ever present and ready for their wants. It is there without man's intervention or aid. When the harvest is gathered the sower finds a rich reward that has cost him comparatively little expenditure of money, care or attention.



MICHIGAN.

Chart showing Coast line on Great Lakes of Canada, Ohio, Illinois, Wisconsin, and Minnesota, compared with Michigan.

The State has taken pains to surround the game fish, like the brook trout, the game birds, and the game quadrupeds of this State with the most rigid laws protecting them from interference during their period of reproduction, and for a sufficient time thereafter to protect the young until they can care for themselves; yet the State has not invested a single dollar in the propagation of any of these, except the brook trout, neither does it derive any substantial return from their capture. Stringent laws have been passed and are rigidly enforced to protect the peach orchards of the State from the scourge known as the "yellows." Such laws are just, and have been adopted and are rigorously enforced in the interest of the public good; but the great commercial fisheries of the State that yield a million of dollars yearly at the wholesale price, are constantly subjected to the most destructive methods of fishing, with the certain prospect that in a short time they will become absolutely extinct. If there is any one thing in the State that deserves protection, it is the commercial fisheries. It is not only a matter of the greatest concern to our present population, but it is of vital interest to those who are to come after us.

The duties laid upon the State Board of Fish Commissioners require them to submit a report to the Governor of the conduct of their work, and further requires them to submit suggestions from time to time as to the needs of the fisheries. In pursuance of this duty we have frequently suggested such reforms as seemed to us necessary and proper, and have asked for action thereon. We have no interest beyond that which concerns the public; and although such proposed measures may be defeated, our plain duty and our inclination, when possessed of all the facts, urge us to again bring this matter to your attention.

We recommend that at the coming session of the legislature a bill be passed authorizing the imposition of a license fee upon all nets which may be hereafter fished in the great lakes and their connecting waters in Michigan, and that the fund obtained from such licenses shall be turned in to the credit of the State Board of Fish Commissioners, to be used in the propagation of fish for stocking the waters of the State.

The state of New York has a law now in force similar to this, licensing the use of the oyster beds within the state jurisdiction. The Dominion of Canada has for years imposed a license on nets and boats engaged in the fisheries, and the states of Ohio and Minnesota have imposed license fees on the fishermen. The wholesale commercial fish business carried on in this State is to a certain extent in the hands of individuals and corporations living outside of the State, who come into our waters and enjoy the privilege of fishing here in common with our citizens, and it seems but just that they should contribute in this way to the support of the work of artificial propagation.

The work of the board has been chiefly directed to the propagation of the fish that are indigenous to our waters, and the propagation of such fish is more likely to be successful than to attempt the introduction of foreign species.

A surer result is obtained in fish culture where natural conditions are regarded in planting, by putting into our lakes and streams such fish as are naturally found in them. The conditions of an abundant supply of fish food for the fish so planted and of the right kind, is more likely to be found, and success is more certain than in attempts to introduce new varieties into strange and new surroundings, where fish food conditions are unknown.

During the past twenty-five years many attempts have been made by commissions and individual fish culturists to introduce new species of fish into the waters of this country. Many of these attempts have been failures. It may be and probably is the fact that too much of the work has been done without thorough preliminary inquiry having been made as to conditions of fish food in the waters where they have been introduced, the life history of the fish itself, and other things, which, if known, might have saved useless expenditure of time and means, and chance of failure.

Our experience with our own waters has shown, however, that the much abused and despised carp has come to stay, whether welcome or not. Much of the criticism devoted to this fish has grown out of a lack of knowledge on the part of the general public as to his status as a food fish, and an increasing prejudice among those who think that every new fish must be possessed of the gaminess of the brook trout or bass, coupled with the edible qualities of our best fresh water fish. A fish may possess none of these game qualities and yet be of much economic value, and such a fish in our estimation is the carp. He is a foreigner, but never has a foreigner more readily adapted himself to his new environment than the carp.

It is a vegetarian in habit, and in foraging for the roots of aquatic vegetation he stirs up the mud of the water he inhabits, and the mistaken idea has gone abroad that he is a scavenger and uncleanly in habit. Nothing could be farther from the truth. With greater propriety might this criticism be applied to the hog, whose habit as to uncleanliness is proverbial, and yet pork is one of our chief articles of daily diet in some form or another.

In Europe for centuries the carp has been highly esteemed and was regarded as the food of kings, and great pains were taken in their breeding and care. Today it is highly thought of in Germany, and when it becomes better known in America, it will be more highly valued.

The carp is forceful enough to make head however against unreasoning prejudice. His flesh is coarse, but outranks the flesh of the coarser varieties of our native fish, like the pike, sucker, red horse, moon-eyes, etc., of which large quantities are annually consumed.

Figures tabulated from the New York market reports extending over a number of months show its selling price to average about six cents per pound. It is also true that it fetches a good price in the Philadelphia and Washington markets. An inquiry made last year by this board among Detroit fish dealers showed that the amount disposed of in this market reached seventy tons for the year.

Singularly enough the carp that reach the Detroit market have come into the great lakes as the result of an accident. The board has never deposited a carp in the waters of the great lakes. But several years since distributions of these fish began to be made to applicants in the interior of the State to be placed in spring holes and in the sources of spring-fed streams. The applicants constructed what they called dams for the confinement of the water and the fish. Matters went on in the even tenor of their way until some passing summer cloudburst or autumnal freshet carried away the frail barrier and water and carp escaped into the stream and were lost to the proprietor. But the public was the gainer by this natural distribution. The fish gradually dropped down the stream to some larger current and eventually found their way by the Huron or some other stream to Lake Erie.

We assert that the people will look upon this fish with more favor as it becomes better known. We are also satisfied that it will become an important and cheap food for the poorer class of people who cannot afford to buy the more expensive kinds, but can afford to have a Friday dinner off the cheap and good foreign fish, once considered fit only for royalty.

A recent writer in the daily press, in discussing the carp, has written very intelligently on the subject, and we quote him in this connection.

"These are the days of bluff and bluster; of rank intolerance and unreasoning prejudice. A newspaper scribbler who could not for his life tell whether fish eggs belong to the animal or the vegetable kingdom, or 'half way between the two,' as expressed recently in a Philadelphia exchange, starts an absurd rumor about the carp as a destroyer of game fish and their eggs, and men whose duty it is to know better join in the hue and cry.

"Many years ago a German named Poppe, residing in California, introduced a few carp from his native country to his adopted home, and, in a few years, the fish were spread in many parts of the state and had been transported to the Sandwich Islands. Less than twenty years ago the first United States Commissioner of Fisheries obtained some of the same species from Germany for stocking suitable waters in the United States.

"Both Baird and Poppe were well aware of the esteem in which the carp is held in Europe and of the great industries springing out of its culture in ponds. Each was animated by the praiseworthy desire of acclimating this valuable fish in portions of the country which were not well supplied with choicer fishes. The primary object of its introduction was to furnish a species that has a record of successful domestication, rapid growth and good food qualities under proper conditions.

"Owing to the fact that carp could be had for the asking and to the misapprehension that they can be grown in any kind of water, the fish were distributed throughout the whole country for stocking ponds; often poorly made, from which, in innumerable cases, they escaped into open waters. Many of them also were intentionally planted in streams. In this way the carp has become abundant, and, in some localities, it is very much abused.

"It is said to be worthless for food and a destroyer of game fish and their eggs, as well as of the water pants upon which wild ducks feed. Carp will eat the bulbous roots of water plants without doubt, but there is ground for more than a suspicion that ducks were driven from the marshes near San Francisco by drift nets rather than by the feeding habits of the carp. It is surprising that the newspaper ichthyologist has not charged the big carp at the mouth of the Susquehanna with the destruction of the wild celery beds and the consequent scarcity of canvas backs. Fortunately, the cause of the disappearance of the celery is too widely known to warrant the charge.

"Does any one seriously entertain the belief that a fish like the carp, without teeth in its jaws and with only a pair of weak comblike laminæ in its throat, can seize and destroy a game fish? As a matter of fact, the game fish find in young carp a never failing and ever welcome addition to their food supply. Has any one found eggs of any sort in the stomach of a carp? We have yet to see the first authentic record of it. But, even if it be true as stated, the carp is no worse than the rainbow, the lake trout, the Dolly Varden and some kinds of salmon; it is certainly not trout, the Dolly Varden and some kinds of salmon. We hear no outcry against these noble game fishes and this valuable commercial species because of their well known failing.

"The carp, when in season, is a good fish, and it is marketable at a fair price, comparing in this respect with pickerel, pike, perch, cod, eels and the red horse in the winter season. At Quincy and Chicago, Ill., Sandusky and Cleveland, Ohio, Philadelphia, Baltimore and Washington, to our certain knowledge it is held in good repute. A prominent restaurateur in Cleveland puts it on his bill of fare alternately with whitefish, and he says he has as many orders for carp as for whitefish. That it is winning its way in Philadelphia is shown by the following item from the 'Philadelphia Times':

"'The much despised carp is proving itself a most valuable food fish, as well as a money getter, and work in catching them in the streams of Salem county, N. J., continues on a large scale, notwithstanding the ice. Fish culturists state that carp hibernate in the mud during the cold weather, and experience apparently does not bear out the assertion, as many are now being caught. Holes are cut through the ice and a net cast, and hauls made every half hour. The fish are worth five cents per pound and the supply will not begin to equal the demand. In quality they taste much better now than in the summer, and they are considerably larger. One firm in Philadelphia has paid to men in Penn's Grove over $3,000 since last July, while fishermen in Upper and Lower Penn's Neck have received $5,000 for their past six months' catch. Three firms are now buying them.'

"In Quincy, Ill., many hundreds of poor families would go hungry but for the obliging carp introduced by the Fish Commission, and now so plentiful as to add materially to the food supply.

"But it is not to be expected that arguments based upon the use of the carp for food and its value to the commercial fishermen will avail to stem the torrent of abuse now rolling and surging on the shores of lake and stream, and echoing and reverberating in shallow caverns which are the empty heads of its false accusers. What does it matter whether the poor have bread and the toiler has his recompense so long as the know-it-all scribbler has his fling!"

The rainbow trout (salmo irideus), a native of the Pacific coast streams, has thriven remarkably well in our rivers of large volume. It is a vigorous and sturdy game fish, and grows to larger size as a rule than the brook trout (calvelinus fontanalis). One of the interesting things regarding this fish has come recently to our attention. Two excellent individuals of this species have been taken in nets engaged in commercial fishing in the great lakes during the last year and a half. On or about July 15, 1895, a rainbow trout, weighing 5½ lbs. and in prime condition, was taken in one of the nets of Messrs. Ainsworth & Ganley, fishermen of Sault Ste. Marie, at the Lizard Islands on the north shore of Lake Superior. This is the first reported rainbow trout taken in the great lakes.

The second individual was caught in a pound net fished by Mr. Samuel Butterfield at the Cheneaux Islands, September 29, 1896. This fish weighed 3 lbs. 2 oz., and was also in perfect condition. On the following day it was sent to the Sault Ste. Marie hatchery alive, and placed in a pond where it remains in fine condition.

From this we may infer that the rainbow takes kindly to the upper lakes, and it is possible they may increase in numbers sufficiently in time to afford excellent sport to the anglers on those waters. This fish has no superior among trout in our waters for gaminess, and is a desirable fish in every way. His advent in the great lakes so far as we know is similar in manner to that of the carp. None have been liberated in any of the lakes, and he comes undoubtedly from some of the streams of this or neighboring states which have received liberal stockings. Our experience for the first few years in handling this fish was not satisfactory. They did not manifest themselves in the smaller streams after liberation, although in larger streams they succeed well, and it was inferred that they preferred more ample limits for success and passed into larger waters. Their capture in the great lakes seems to verify this view, and it is to be hoped that they have found in the pure waters of Huron and Superior a congenial habitat.

The work of the Division of Scientific Inquiry established by this board, which was in operation for more than two years, was dropped at the beginning of the biennial period covered by this report, because of lack of funds with which to prosecute the work. It was unfortunate because the work had been well organized, and the cost of its maintenance was comparatively small. The division was organized primarily for the purpose of investigating the life habits of the young whitefish, the foods upon which it lived, where it was found at different seasons and in what varying conditions of abundance. The determination of the conditions that controlled their movement, whether food, temperature, or other causes, are all of great importance to the fish culturist, as much so as an intimate knowledge is essential to the agriculturist of a knowledge of the conditions of the soil and its constituents. A thorough knowledge of these things would aid in determining whether one locality afforded better chances of success for the growth and life of the young fish planted. Incidental to such investigation many collateral investigations are demanded, which though seemingly not closely related to the main investigation, are as a fact essential to a full knowledge of the subject in order that just deductions may be made bearing upon the questions to be solved.

It is to be regretted that occasion arose making it necessary to drop this work, after it was once well under way and the force had been organized, and it will be a matter of some difficulty to again bring together so efficient a corps of investigators again, but we hope to be able at an early date to again start on this valuable enterprise. The work thus far done has been of practical and scientific value. We have found a locality well suited for the continuation of this work, where constant supervision during the year may be had over the fish to be examined, and with a small outlay of means a permanent station can be here established. Should our funds warrant we hope soon to again begin this most important work. (*a*) Five bulletins, embracing reports of the work of the different divisions under this bureau, have been issued in the last biennial period. These bulletins have challenged the attention of scentists at home and abroad, and have added to the stock of common knowledge on the subjects of which they treat.

The growing scarcity of salmon trout in the lakes compels us to recommend that the artificial propagation and distribution of this fish be entered upon. The importance of this fish in the market is next to that of the whitefish. Charlevoix is the center of the best salmon trout grounds on the lake system, and affords advantages over any other point. It is near large spawning beds and distributions of fish can be made at small cost, and with prospects of excellent success.

The citizens of Charlevoix have expressed themselves as interested in the establishment of such a station, and if they will contribute to the board a site and a sufficient water supply for the station, we think the State should provide sufficient funds with which to erect and properly equip a hatchery. The cost of buildings and equipment will not exceed five thousand dollars and would repay the investment.

In the spring of 1893 we established an experimental station for the hatching of small-mouthed black bass at Cascade Springs. The multitude of inland lakes in this State show the effects of overfishing and the greater number of them require restocking. There were some questions to be solved regarding the hatching of this fish, and its action under domestication. The three years of experiment at this station have shown that with proper methods the work can be made successful, and that it should be brought to its fullest possibilities. When it became known that this work was under way, applications began to come in and those now on file in the office would exhaust the capacity of a large station. No other new work undertaken by the board has met with greater favor than hatching and planting of black bass. The bass is natural to nearly all our inland lakes and many of our streams, and is so well and favorably known that the work of restocking our inland lakes with this fish has met with popular approval.

We have secured a very advantageous location for a new bass station on the line of the Chicago & West Michigan Railway, near Grand Rapids, at a very low figure, and shall commence the construction of the necessary ponds with the opening of spring. The expense for the completion of this station will not be large. It is quite likely that if the demand for black bass increases at any such rate in the next five years as it has in the past two, there will be a necessity for equipping other stations in different parts of the State to meet these applications.

The board has decided to discontinue further distributions of gold fish. They are in no sense a food fish, and being used solely for the purpose of display, we shall hereafter discontinue donations of this kind, except to a few of the public parks.

For the purpose of making distributions of young whitefish in localities where the best results may be secured, we have made every investigation possible to ascertain the exact location of the natural spawning beds of the whitefish in the great lakes of this State. The most careful inquiries have been made of fishermen on different parts of the lake coast, and the information thus gained has been made a matter of record in the office of the board. This information has been put in shape and furnished to the captain in charge of the car for his guidance in planting. Special care has been taken to impress upon those charged with this work the importance of putting the young fish on grounds indicated by the fishermen as the spawning beds, and these directions have been fully carried out. In doing this the board is following out nature's plan in liberating the young fish on the beds where the fish naturally spawn, and we believe with the best chances of finding the natural food taken by them at that age.

In nearly all instances where tug service is performed in connection with the plant, it has been done by the local fishermen of the port from whence they have been distributed, and they have been directed to take the fish to the places we desire to reach, and in case of doubt as to the locality of a spawning bed, their advice has been asked for. In nearly all instances this tug service has to be paid for by the State, and in the course of a year amounts to a considerable sum. Often the owner of the tug is the principal beneficiary of the work done by the State in planting fish, and it would seem that such service should be rendered gratuitously, yet no such disposition has yet been manifested.

In January, 1894, the term of Mr. Hoyt Post as commissioner expired, and Mr. Freeman B. Dickerson of Detroit was appointed his successor.

DETROIT STATION AND RIVER FISHERIES.

BY SEYMOUR BOWER.

The last biennial report of the operations at this station covered a period ending December 31, 1894. At that time the hatchery contained probably the largest and finest lot of whitefish eggs ever assembled under one roof. The capacity of the hatchery for green eggs was overreached, compelling the immediate shipment of a considerable surplus.

The weather conditions had not been the most favorable for a large catch in the river, as storms interfered to some extent with the fishing, but were exceptionably favorable to induce free spawning and a high percentage of fertilization. On November 13 the temperature of the river had dropped to thirty-eight degrees, and it did not rise above that point again during the remainder of the season; so that at least ninety-five per cent of the females spawned were handled from water ranging in temperature from thirty-eight down to thirty-four degrees, the best possible range to secure the most favorable results.

There were shipped from the Detroit hatchery during the season a total of eighty million three hundred and thirty-eight thousand whitefish eggs. The last lot went out February 20, completing a transfer of 33,000,000 to the branch hatchery at Charlevoix, to be hatched there and placed in northern Lake Michigan. On February 25 a careful measurement was made of the eggs remaining at Detroit, showing 94,987,000 on hand. At that time the eggs were all eyed and the dead and unimpregnated had practically all been eliminated.

The hatching season opened several days later than usual at this station. Generally a sufficient number of fry are out to make one or more shipments in March, but as late as April 8 this year the water was down to thirty-four and one-half degrees, or only one and one-half degrees above the lowest point reached during the winter, and it did not go up to forty until the 16th. Notwithstanding the low temperature, a sufficient number of the oldest eggs had hatched by April 6 to enable us to collect from all the tanks a light carload of fry, and the car was accordingly started on that date—just twenty-three days later than the first shipment last year. The eggs hatched freely and quite steadily from and after the 10th and the hatching season closed seventeen days later, or April 27.

The total number of fish hatched and planted at this hatchery was 93,400,000, shipped out in 2,931 cans. The number of eggs laid in was, in round numbers, 188,000,000, portions of which were shipped away in the eyed condition as above stated. Comparing this number with the total output of eggs and fry, we find that the percentage of results was ninety-two and one-third. It is hardly fair, however, to regard this as the hatching percentage for, although the greater portion of the eggs shipped were cleaned up and in the eyed stage, some went out as green eggs, or before the percentage of loss had been sustained. Making the average allowance for losses on the latter, however, we find that the actual hatching percentage was a trifle over ninety.

In all cases the fry were planted in a vigorous and healthy condition, wholly without losses either in the tanks or in transit. This result was due chiefly to the fact that the fish were shipped practically as fast as hatched, thereby forestalling weakness and exhaustion for want of food. The tanks were alternately emptied and cleaned every two or three days, thus insuring against holding any fish longer than three days.

When we consider that nature, although generous to the female whitefish in the number of ova, leaves that ova when naturally cast entirely unprotected and exposed for months to manifold agencies of destruction, the enormous saving and multiplication of results through the manipulation and protection called artificial propagation, are at once apparent, but in the propagation of whitefish on a large scale the great advantage of art over nature is reversed at the hatching point. We have suddenly thrown on our hands millions of young animals that must soon have food. The question is, shall we attempt to supply this food ourselves, or release them where nature has provided an abundance.

The suggestion is frequently made by visionary enthusiasts that whitefish fry should be confined and fed until they have obtained some growth. It is true that they may be reared under surveillance on their natural food or a substitute, but the percentage that may thus be raised is so insignificant that the labor and expense are entirely out of proportion to the results. The question of cost, coupled with meagerness of results, precludes consideration of the plan. It is not only impracticable to provide the storage tanks or enclosures that would be required to carry fifty to one hundred millions of fish—presupposing it possible to keep a profitable percentage alive and growing under the restrictions necessarily imposed—and to collect the volume of natural food necessary for their sustenance, that such a course seems wholly unnecessary and unwarranted. Under natural conditions and limitations, the only practical and rational plan is to release them at once where they may disperse and range at will in the waters of the great lakes, nature's great free store house, inexhaustibly stocked, not only with the minute animal forms that constitute their earliest food, but also with the larger and varied forms essential to successive stages of development.

Having done all that we can do with profit when we have brought the embryos to the point of hatching, the question of how much longer they should be held, without any attempt at feeding, becomes an important one. Whitefish fry, as such, are never more vigorous than at the time of hatching; they are free swimmers and begin to take food within a very few days. It would seem, therefore, that the sooner they are set free in their native habitat, to mingle with nature's fry, the better. There is nothing to be gained by holding them and there is great risk in carrying them beyond the time when nourishment other than that supplied by the food sac is essential to normal development.

The question of liberating the fry to the best advantage with reference to food supply and other favorable conditions also seems an important one, and the aid of scientists might well be invoked to throw more light on this and kindred questions.

The volunteer work on the great lakes by a corps of scientists in the summer of '93, and again the following summer, contributed much that is of interest and practical value to the fish culturist, but to acquire the greatest measure of knowledge of a practical nature, these investigations should be continued in time and extend over a wide territory, so that the life history of all forms of water life under all the varying conditions of environment, and the relation and interdependence of these forms might, as far as possible, be known.

For example, it is entirely feasible to determine approximately—aside from the destruction wrought by spawn eating fishes—the hatching percentage of whitefish eggs in a natural state, and thus demonstrate conclusively the relative merits of artificial and natural production. Collections from the spawning beds from time to time during the spawning season would show the natural percentage of fertilization, while later collections would show the loss to the eggs from sediment and the insidious spread of fungus. But this, of course, cannot be done in the summer. Nor can the range and abundance of the earliest food forms selected by the infant whitefish be determined in summer, when the temperature of the surface levels has gone to the opposite extreme.

We know that whitefish fry do not take their food from the bottom; from the moment of hatching they are free swimming animals, whose earliest food consists of other free swimming animals. If this food is more abundant in one locality than in another, we should know it. If there are areas having no food for the young fish, and other regions of great fertility, we should be able to define them. If, on the other hand, we find that there are no barren areas to be avoided, that the food is distributed with a considerable degree of uniformity, then our aim and solicitude would lie chiefly in the direction of releasing the fry where they would be least likely to fall a prey to natural enemies.

While it is not known whether the food of the fry is any more or any less abundant within easy range of the reefs and shoals selected by the adults for spawning purposes, and while the best place to plant them is, for want of definite knowledge as to food conditions, largely a matter of conjecture, the reasonable supposition is that they should be placed only over spawning grounds. Partly in deference to the prevailing notion, and partly because it may be said in defense of this course that when so planted the hatchery fry are at least on an equal footing with nature's fry, the distributions have been confined as nearly as possible to spawning sections. In Lake Michigan only two lots were liberated south of Frankfort, as the spawning grounds south of a line crossing the lake at that point are few and unimportant.

By taking advantage of the great natural fecundity of the whitefish in connection with the adaptability of the embryos to artificial propagation, hatching results are multiplied enormously; likewise it seems not improbable that there are other conditions within the realm of discovery which, if taken advantage of, would enable us to still further discount nature.

When we consider the character of the spawning grounds, that such grounds are practically destitute of vegetation and therefore wholly unfavorable to the development of fundamental water life, it would seem that nature directs the parent whitefish to certain grounds solely with a view to the protection and welfare of the ova, not the fry. The character of the bottom is a matter of some consequence to such kinds of fry as are helplessly weighted down with a heavy food sac, but the whitefish is not thus handicapped; it rises and swims freely the moment it escapes from its embryonic prison. From a condition of utter helplessness, except such incidental protection as the formation of the bottom may afford, all impedimenta is suddenly thrown off, and there is set free a little animal whose immediate future is in no-wise related to the nature of the bottom from which it arose, except as the latter may have a bearing on the abundance or scarcity of food in that vicinity.

The nature and formation of the bottom or grounds where whitefish spawn also constitute a strong argument in support of the proposition that the spawn is deposited in nature wholly with reference to the ova. It is cast on reefs and ledges of limestone rock, sometimes honey-combed and resembling a petrified sponge in form, sometimes on a solidly paved cobblestone bottom, the latter sometimes interspersed with boulders. So far as is known—and the territory has been pretty thoroughly canvassed throughout the great lakes—ripe whitefish of both sexes may be taken at the same time only from grounds of his character. Indeed, it seems almost necessary that grounds of this nature must be used if any of the ova are to survive or escape the many dangers with which they are beset for a period of five or six months, as the cells of the honey comb reefs and the interstices and crevices between the cobblestones afford some degree of isolation and immunity.

Many fishermen assert that whitefish are strictly local in their habits, that they only visit certain feeding and spawning grounds and never range beyond these limits. This may be true where good feeding and spawning grounds are adjacent, but it hardly seems likely that where such grounds are widely separated the same invariable path between the two is always taken. However that may be, the fact that certain types visit certain grounds year after year has given rise to the absurd notion that the fry from hatcheries should at some future time return to the exact spot where planted, and if they fail to do so, whether whitefish have ever been taken in that locality or not, the whole work of propagation is condemned and denounced as a failure. When planted on spawning grounds there may be some reason to expect them when mature to visit the spawning grounds of that neighborhood and to continue to do so indefinitely—if not caught before they have had an opportunity to do so—but when deposited elsewhere and wholly without reference to spawning grounds, surely the reproductive instinct will never bring them to a point of planting again unless it lies directly in the path towards a spawning ground; and though every fish so planted survive to maturity, it would be the merest chance or accident if that particular spot were visited or passed while foraging for food. An impartial estimate of the results of planting over wide areas must include the catch of a lake as a whole, considered in conection with the nature and extent of the fishing. A fair index of the tendency towards an increase or decrease in the number of adults is afforded by the number that annually assemble, or that attempt to assemble on the spawning grounds. Seized with a common impulse they move instinctively towards the reefs and stony sholes for a definite purpose; but the claim that fry planted indiscriminately over wide areas should return unerringly to the exact spot where set free, seems almost too absurd to find support.

During the summer of 1895 the inside of the hatchery was painted two coats throughout, and the entire jar and tank equipment was torn down and reconstructed. The fry tanks and one of the double jar batteries were rebuilt wholly of new material, but the other jar battery was made up of troughs and tanks culled from the old material and patched and repaired. The inside joints and corners and seams of all the tanks were filled with hot pitch; then the whole inside surface was treated with three coats of coal tar.

DETROIT RIVER FISHERIES AND WHITEFISH WORK. SEASON OF 1895-96.

Only three fisheries were operated by the commission this fall—one at Grassy Island and two at Belle Isle. The fishery at Stony Island, now run by private parties, was a failure on account of the extreme low stage of the water in connection with the peculiar local conditions at that place. The fishery in front of Fort Wayne and known as the Fort Fishery, from which we have usually secured 15,000,000 to 30,000,000 eggs each season, is lost to us irrevocably through the action of the government in parking the river front and demolishing the fishery. The buildings and platforms at this fishery rested on piles, about twenty rods from shore, and the grounds that they occupied are now just inside of the sea wall that has been laid to define the new shore line and enclose the new park area. Notice to vacate was received in September, and soon after a crew was sent there to dismantle the buildings. These were of little value, except the one used as quarters for the fishing crews, which was nearly new, and this was transferred by scow to one of the Belle Isle fisheries, where it was needed. All other material of value was likewise taken to the Belle Isle fisheries.

Following the removal of the Fort buildings, a crew under the direction of Dwight Lydell as foreman, was put on at Belle Isle to make necessary preparations for the fall fishing. The seines that had been stripped and stored since the preceding season were overhauled, mended and hung, and three new ones added. A number of the old crates were beyond repair; the new ones to replace them were made considerably shorter, for convenience in handling. The usual roughly constructed temporary buildings, docks and platforms required at the two Belle Isle fisheries were provided. As the construction and dismantling of these temporary necessities each season involves considerable expense and waste, it is to be regretted that sufficient funds are not appropriated to provide for their permanent construction, finished and ornamented in such a manner as to meet the approval of the Park Board, so that their removal would not be required each year on account of crude and unsightly appearance. This would not only be more economical in the long run, but also more desirable in every way.

At Grassy Island a crew commenced work October 8th, to make needed repairs to crates and seine boats and to do the necessary dredging to remove the annual accumulation of mud from the ground in front of the apron and out toward the channel bank.

Preliminary or trial hauls to clear the grounds and to note whether the fish were running were made occasionally by the repair crew. Fishing by a regular crew was begun at Grassy Island October 17th, at the Willis Fishery at Belle Isle on the 18th, and at the East Point Fishery, Belle Isle, on the 21st. The crews were doubled at the Grassy and Willis stations on the 29th and at East Point a day later. The bulk of the run came on about a week earlier than usual, and fishing was discontinued at a correspondingly early period. The last hauls were made at Grassy on the 16th of November, at the Willis Fishery on the 17th, and at East Point on the 18th.

The season as a whole was favorable as respects fishing, but unfavorable for spawning. The cold, rough weather that prevailed throughout the month of October brought the fish into the river early, but they were not ripe, and the fine weather that followed was not at all favorable to maturing the spawn of whitefish confined in crates. The water temperature had dropped gradually to 40 degrees by November 1st, and the conditions were all right up to that time, but instead of going lower, or even remaining stationary, as it should to have forced the spawning, it rose to 46 degrees by the 7th and did not drop back to the 40 notch again until the 19th. A comparison of the water temperatures with those of a corresponding period last year affords a complete explanation for the difference in spawning results.

The combined catch of the three fisheries was considerably greater than from the same grounds last year. Grassy Island shows a decrease, and the Willis ground a slight increase, but the catch at East Point was nearly doubled. A very unusual feature of the season's catch was that the females outnumbered the males. More of the former were taken than last year, although one less fishery was operated.

At Grassy Island low water was responsible for delays that reduced the total number of hauls during the season about 25 per cent. Frequently the water in front of the apron was too shoal to float the boats after the seine had been shipped, causing a considerable loss of time in getting away. The average catch per haul was, however, 15 per cent greater than last year. The largest single haul of whitefish at Grassy during the season was 62.

At the Willis Fishery the number of hauls was 16 per cent fewer than last year, due to an increase of 16 fathoms in the length of the seine, thereby requiring more time to ship and to land it. The average per haul was 20 per cent greater than last year. The largest single haul was 37.

At East Point 28 more hauls were made this year than last and the increase in the average catch per haul was 73 per cent. Largest single haul, 57. The service at this fishery was very satisfactory this season. A special watchman was stationed there during the season and a more skillful seine thrower was secured for the second crew.

The following table shows the season's catch in detail:

Fisheries.	No. hauls.	No. females.	No. males.	Total.
Grassy Island	470	2,941	2,323	5,264
Willis (Belle Isle)	677	2,198	1,833	4,031
East Point (Belle Isle)	437	1,697	2,531	4,228
Totals	1,584	6,836	6,687	13,523

On the night of November 26th a heavy southwest gale lowered the water at Grassy Island about six feet, breaking all low water mark records. As our crates there rest on the river bed, it was thought for a time that most of the fish would have to be taken out. The females that had not spawned and most of the males were moved to crates some distance away in deeper water, placed there expressly to meet such an emergency, but even there the water was dangerously low. For a short time there was less than a foot in the crates and many of the fish were partly out of water, but the tide turned barely in time to save them.

A few eggs were taken as early as November 1st and as late as December 12th, but the heart of the spawning season was between November 8th and December 1st. Number of females spawned at Grassy, 2,476; at Belle Isle, 3,103; total, 5,579. Number of females at Grassy that failed to spawn, 465; at Belle Isle, 792; total, 1,257. Average per centage spawned .816, or more than 11 per cent less than last year.

The total number of eggs taken on the river was in round numbers 169,000,000, an average of about 30,500 per female spawned. Another million was received from other sources, making the total receipts at Detroit about 170,500,000, or 18,000,000 less than last year. Belle Isle furnished 16,000,000 more this year than last, and Grassy 4,000,000 less, a net gain of 12,000,000 from these sources; but contributions from two fisheries that furnished 31,000,000 last year were entirely cut off this year, leaving a net loss on the river of about 19,000,000.

The average weight of the whitefish taken this year was two pounds and fifteen ounces, an increase of 10½ per cent over last year and 20½ per cent over two years ago.

The following shipments of whitefish eggs were made from the Detroit hatchery during the season:

Nov. 25, 600 quarts to Charlevoix.
Dec. 12, 300 " "
" 20, 382 " "
" 30, 231 " Sault Ste. Marie.
Jan. 19, 200 " " "
Total, 1,713 quarts, or nearly 63,000,000.

The 600 quarts shipped November 25th to Charlevoix were all lost through the wrecking of the fish car near Traverse City.

By March 1st the eggs were cleaned up and in fine condition. A few fish were observed in the tanks as early as March 13th, but the hatching season cannot be said to have commenced until the 25th. The weather remained cold for a number of days, however, and the hatching was retarded. Only about 5,000,000 had hatched up to April 8th, on which date the car was started. After that the water warmed rapidly and the eggs were all out on the 18th. The last shipment of fry was made on the 22d. The fry were shipped and planted in excellent condition, the plan of the past two seasons being continued, namely, clearing and cleaning the tanks alternately as often as once in three days. Total number of cans shipped, 2,378; number of fish, 66,000,000.

It has been freely claimed and with considerable persistence that the water in which the eggs are incubated at the Detroit hatchery is warmer than the water in the river, on account of being piped about two miles, and that in consequence the eggs hatch earlier than in nature; but the record of surface and bottom temperatures of the river that has been kept during the past season proves the falsity of this claim. The hatchery and river temperatures are practically identical. Still further and equally conclusive evidence is furnished by the fact that the incubating season at the Sandwich hatchery, which is located on the bank of the river and pumps directly therefrom, is identical with ours.

RIVER FISHERIES AND COLLECTION OF WHITEFISH EGGS, SUMMER AND FALL OF 1896.

During the summer the little building moved from the Fort Fishery last fall to the East Point Fishery, Belle Isle, and used as a mess house and sleeping quarters for the fishing crews, was remodeled externally, and converted into a neat little cottage similar to the one at the Willis Fishery.

On September 15th the crew commenced overhauling seines at Belle Isle. Some of the seines were badly torn and worn, but it was decided that with four new strips they could be made to answer for the season. The repair force was increased October 1st and the usual work of building docks, platforms, etc., was taken up.

A number of new and improved crates were made for the Belle Isle and Grassy Island spawning stations, the new features being suggested chiefly by Foreman Lydell. Two and one-half inch strips were used instead of six inch fence boards, thus increasing the area of the openings and improving the circulation. For convenience in moving and storing, the new crates are bolted instead of nailed at the corners, so as to "knock down" into five sections—the bottom, two ends and two sides. But the most important improvement introduced is a false bottom which can be raised or lowered at will. This bottom is made of two and one-half inch strips and is held down by wooden pegs passing through an upright standard at each corner into the corner post. When the pegs are pulled, the bottom floats up to the surface; or, it may be stopped and held securely and indefinitely at any intermediate peg station. Heretofore in handling a crate of fish, they have been massed towards one end of the crate by a sliding gate, but when the water is so roily that only those near the surface may be seen, quite a good many are overlooked and escape handling at the proper time. The gate is still used, but the movable bottom still further contracts the lines and brings every fish into view, regardless of the condition of the water.

Early in October a repair crew commenced to lower the platform at the Grassy Island fishery and to make other preparations for the fishing season. The object in lowering the platform was to facilitate the handling of the seine. When this platform was built, the average stage of water was considerably higher than that of the past few years, and what is really needed now is an extension of the dock and platform into water of sufficient depth to float a loaded seine boat at all stages. Likewise the canal or runway connecting the apron with the crate should be moved farther out. As it is now, every southwest gale of any consequence lowers the water so that the canal is high and dry, and the fish have to be carried in tubs from the seine to the crates.

Regular fishing was begun at Grassy, October 20, at Belle Isle two days later, and the crews were doubled all around from the 27th to the 29th. Fishing was begun an average of one day earlier than last year, and was carried on five days later. The last hauls were made at Grassy, November 21, and at Belle Isle on the 23d.

The weather was unfavorable throughout the season for fishing on the American shore. Our catch was 16 per cent short, or 2,260 fish less than last year. High southeasterly to southwesterly winds prevailed almost continuously during the best of the season, interefering to a considerable extent with the proper handling of the nets, and also influencing the movement of the fish towards the lee or Canadian shore.

The catch in detail is shown in the following table:

Fisheries.	No. hauls.	No. females.	No. males.	Totals.
Grassy Island	626	2,228	2,366	4,594
Willis (Belle Isle)	814	1,550	1,697	3,247
East Point (Belle Isle)	573	1,458	1,964	3,422
Totals	2,013	5,236	6,027	11,263

A very few eggs were taken October 29, an unusually early date, and the soft condition of the females indicated an early spawning, but a long spell of warm weather followed and only 66 fish had spawned up to November 13th. After that the eggs flowed freely, as is usual, from the fish that were within a day or two of spawning when caught. The farther they are from spawning when taken, the greater the number that will fail to mature. Invariably a majority of the latter come from the early caught fish, and the defection is very largely increased with a rising temperature. Early caught fish are often brought almost to the point of spawning by a rapid cooling of the water, then a change throws them back so that many are never brought to that point again, while those that finally do mature are the very last fish stripped during the season. Probably more than 50 per cent of the females caught prior to November 2d, this season, did not mature their spawn.

A comparison of water temperatures during the three spawning seasons ending with the present forcibly illustrates the influence of range and rise and fall on spawning results, and proves the value of a low and narrow range as well as the adverse influence of a rising or relatively high stationary temperature. In the fall of 1894, 95 per cent of the females spawned were taken from a water temperature of 34 to 38 degrees; 93 per cent of the females caught were stripped and 90 per cent of the eggs hatched. The following year the water dropped to 40 degrees by November 1st, but rose to 46 on the 7th and did not fall back to 40 again until the 19th. The spawning percentage was 81½ and the hatching percentage 76. This year, from November 1st to 28th, the water ranged from 52 to 40 degrees, touching the latter point only once during that time, and averaging 45. The spawning percentage was 80 and, from present indications, the hatching percentage will be from 75 to 80, or about the same as last year.

Whitefish seem specially sensitive to temperature influences when confined and handled in crates. As more than 90 per cent of the females from the river catch are not fully gravid when taken, and must therefore be crated for a longer or shorter period, the significance of water temperatures as a factor is still further emphasized. It is fotunate for this work that a large majority of the females are taken after the fishing season is well advanced, the early runs being made up chiefly of males.

Of the 5,236 females crated, 1,048, or 20 per cent, failed to spawn. Total number of eggs taken, 149,650,000, an average of about 35,000 per female spawned.

The average weight of the fish was two pounds and thirteen and one-third ounces, a trifle less than last year. The females ranged heavier, but there was a considerable sprinkling of undersized males. A whitefish as small as one pound in weight has very rarely occurred in the river runs, but at Belle Isle this season 110 fish of one pound or under were taken. These, of course, were returned to the river alive.

The last eggs were taken December 16th at Grassy Island. The spawning season, however, was practically closed in November, as less than 200 fish were stripped in December. The Belle Isle station was closed December 12th. A sufficient number and variety of fish were reserved from the fall catch to maintain an aquarial exhibit at the hatchery through the winter. The conclusion of the river work, which resulted in placing an even thousand jars of whitefish eggs in the Detroit hatchery, closes the biennial period covered by this report.

PIKE PERCH (DETROIT HATCHERY).

As there were comparatively few applications for pike perch on file in the spring of 1895, and as the funds were short it was thought best to carry them over and discontinue this branch of the service for one or more seasons. Inquiries for suitable inland waters continued to arrive, however, and a sufficient number of applications had accumulated to warrant taking up this work in a limited way in the spring of 1896.

An effort was made to lease the fishing privilege on a well known spawning ground on the St. Clair river, but a prohibitive price was asked. The spawn was therefore secured at fisheries operated from Toledo. The ova was taken during the latter part of the spawning season, or from April 20th to the 27th, the spawning privileges having been controlled by others prior to that time.

At the time the eggs were arriving at the hatchery, the temperature of the water varied from 50 to 52 degrees. By May 9th it had gone up to 60 degrees, the weather being hot. The eggs developed rapidly and showed the eye spots on the tenth day. The oldest began hatching May 4th, the sixteenth day. Most of the entire lot hatched from the 6th to the 8th and all were out on the 9th. The average period of incubation was fifteen days.

On May 10th the fry began to rise and show up freely in the tanks. The weather continued hot and they developed rapidly, restricting the time of holding them in good condition to a shorter period than usual. Distributions were made by messenger, the car being engaged in important work in the upper peninsula. Two messengers were started May 10th and they made a total of eleven trips in six days. By that time, or on the 16th, the fry began destroying one another, and the tanks were therefore cleared and the fish placed in the Detroit river, near Belle Isle. In round numbers, 5,000,000 were planted in the river and 9,000,000 distributed by messengers, who made 34 deliveries for 49 inland lakes.

Pike perch fry for the most part lie dormant and apparently lifeless in the bottom of the tanks for a few days after hatching. In this state they are in no condition to be handled or transported. But within a few days after rising they begin to feed upon one another, so that the time for safe and successful transportation is too limited to admit of widely extended distribution. It would therefore seem to be a good plan to make partial distributions in the form of eyed ova, moving them to the waters to be stocked and hatching them "on the spot" in floating boxes.

The following communication was recently received from Mr. G. W. Jones of Marcellus, Mich.:

"The fish you have sent me from time to time have proven valuable in stocking our lakes and streams in this vicinity, and especially is this true in regard to the pike that were furnished several years ago for Big Fish Lake and Saddle Bag Lakes. Our local anglers are catching a good many this winter through the ice and they weigh from three and one-half to seven and one-half pounds each."

NOTES ON EXPERIMENTS IN FEEDING WHITEFISH FRY ON THEIR NATURAL FOOD.

In the spring of 1895, a few simple experiments were inaugurated on a small scale with a view to noting at what age the fry begin to take food, also to determine the particular forms taken by natural selection during the earlier stages of whitefish life. A number of lots of one hundred to three hundred fry in each were confined in small wire boxes stationed in the Detroit river, some at the surface and others anchored at the bottom, to subsist solely on such natural food as might chance to drift into their little prisons. In size these boxes were 14 inches each way. An opening 10¼ inches square was cut from five of the six spaces of the 14 inch cube and these spaces were covered with brass wire cloth, 24 wires to the lineal inch.

Similar lots of fry were placed in small glass aquaria in the hatchery and fed on natural food collected from the river by means of a towing net. The latter was made of India linen in the form of a cone forty inches in length, twelve inches in diameter at the base or mouth and tapering to an opening one and one-third inches in diameter at the apex, which, of course, was closed when in use. The mouth of the net was provided with an iron band or rim to keep it open. For bottom towing the same net was attached to iron runners. When trailed from the stern of a rowboat, this net simply strained out and focused at its small end the minute animal life that was found in greater or less abundance in all parts of the river from the moment the ice went out, or that open water would be reached.

Of the fry thus confined in the river and at the hatchery, reference will be made here to two lots only, as most of the fish not lost through natural causes, or by accident, were preserved from time to time for examination by a scientist, whose report in detail will show with much greater fulness the results and true value of the experiments.

On April 20th, 360 fry were hatched and poured into one of the wire boxes stationed at the surface of the river, about fifteen rods from the south shore of Belle Isle and at a point where the water is ten feet deep and the current very moderate. The box was tossed about with considerable violence by swells and passing steamers, and no doubt many of the fish were injured or killed in this way. By April 30th, or within ten days, 170 dead fish were taken out, also 72 live ones for preservation by the usual methods, leaving 118 on hand. As whitefish fry confined in tanks and cut off absolutely from food in every form will linger along fifteen to twenty-five days before starving to death, it is evident that the heavy mortality of the first ten days was not due to starvation.

By this time most of the survivors had taken food, and by May 6th a few showed a perceptible growth. On May 12th the box was shifted by some person unknown and 26 dead fish were found. Including these, the loss by death and accident from April 29th to May 21st was 70, and six had been preserved, reducing the stock to 42 fish, which were then growing quite fast.

On May 21st the 42 fish were divided into three lots or boxes. One box containing 11 fish was anchored at the bottom; the other two were barely submerged at the surface. The bottom fish did not grow as fast as those at the surface. Our towings showed that the bottom levels were as rich in food life at that time as the top levels, but the screening surface of the bottom box was found more or less choked with mud whenever inspected, and therefore the volume of water that passed through it—and consequently of the food—was materially reduced.

However, not a fish died from May 21st to June 15th, and they had grown to range from one to one and one-half inches in length. Meantime six more had been preserved, leaving 36 on hand June 15th. On this date the usual inspection showed that all of the boxes had been tampered with by some unknown meddler. The covers were not properly fastened down and eleven fish had escaped. There were also seven of them dead, leaving only eighteen. Seven of these escaped July 2d, through a misplaced cover; and from June 15th to July 23d eight died, leaving three on hand, which were transferred to the hatchery. They were then nearly two inches in length.

It is evident that the Detroit river is quite rich in the food required for the earlier stages of whitefish life, for these boxes were placed where the current was feeble, and the volume of water passing through each would naturally be limited to the single screen facing the current, an area ten and one-fourth inches square. Considering the way in which these fish were handicapped and the many mishaps that befell them, their progress and growth cannot be regarded as otherwise than satisfactory and encouraging. So far at least as accessibility to food is concerned, the fry as ordinarily planted in the river undoubtedly fare much better than did those in the experimental boxes.

On April 2d, 400 fry were hatched and placed in two small glass aquaria at the hatchery and then fed exclusively for nearly four months on natural food from the river, daily towings being made for the purpose. During the months of April and May only nine fish died, but 24 lots of 12 fish each were taken out at stated intervals and preserved for examination of stomach contents, leaving about 100 on hand June 1st. These had grown rapidly, much faster in fact than those in the river, and were in fine condition. They continued to do well until about July 20th, when it was noticed that some began to look thin and that the growth of the others, though feeding freely and apparently doing well, was very slow. They seemed to be almost at a standstill. This change may have been due to an insufficient quantity of food or to causes wholly independent of food conditions, but it seems more reasonable to suppose that the river towings were deficient in some element essential to a normal growth at this stage.

Soon afterwards bread was added to the daily diet, and it was taken with considerable freedom, but the fish continued to drop out from time to time—most of the loss occurring in July and August,—until only eight remained on the 21st of the following February, when they were sent to the Paris hatchery. No towings were made after November 23d, and their diet from that time on was exclusively of bread. When moved they were three to four inches in length, in good condition, but small for their age.

The fry of whitefish are so transparent for several weeks after hatching that when confined in glass aquaria in a well lighted room, the presence of absence of food in the stomach may be determined almost at a glance. The presence of their natural food is especially noticeable, as it casts a reddish tinged line throughout the food canal; and the excrement frequently trails or hangs for hours from the anal outlet in the form of an ash colored string, one fourth to two inches in length.

The larger forms taken by the tow net are plainly visible to the unaided eye and may be seen darting about the aquaria with considerable activity, especially when pursued by the young fish. Some of the latter were observed trying to capture the larger forms on the very day that they were hatched, but the earliest instance in which food was positively detected in the stomach was on the third day.

There is a radical difference between the fry and adult stages of whitefish life, both in respect to the character of their food and the manner of taking it. The fry are provided with small, sharp teeth that enable them to seize the little animals upon which they subsist for a time, but the mouth of the adults is of the sucker form, and therefore unsuitable for seizing active prey, but admirably adapted to taking food from the bottom by suction. Such a complete metamorphosis in these respects indicates that still another type of food may be sought or needed during the intermediate stage, or period of transformation. It is not known at just what age young whitefish begin to lose the strictly carnivorous habit and to seek a change in their bill of fare, but these experiments indicate that a partial change at least is desirable or even necessary between the third and fifth months.

PARIS STATION.

J. W. POWERS, OVERSEER.

The Paris station is the station for hatching brook trout, rainbow trout and brown trout. Until the completion of the Soo station and the installation of ponds there for parent brook trout in the summer of 1896, this station was the only trout station of the commission.

The output varies from two and a quarter to two and three-quarters million brook trout fry. In addition about 275,000 rainbow and brown trout are also distributed. For the past three years this has been supplemented by the hatching and distribution of about three million lake trout which have been hatched here because of lack of room and conveniences elsewhere.

Improvements have been made to the betterments of this station in the two years by the addition of one new spawning pond above the highway and the addition of one pond at the lower end of the group of ponds below the railroad. This has added to the capacity of the station to that extent.

The waste ditch above road has been improved by the removal of the old plank siding which had become badly decayed and replacing it with field boulders similar to those surrounding the new ponds, making a permanent improvement and replacing the unsightly and decaying wood with a neat and attractive embankment. This improvement was carried below the highway bridge and has added much to the appearance and permanent character of the grounds.

The improvement in the construction of the lower new pond necessitated the cutting down of the surrounding grade, required the removal of the surplus earth which was taken to the low ground about the ponds above the road and utilized in that improvement. At that point the ground was low and marshy and covered with flags and at times with stagnant water. This place has been filled in to grade to correspond with the surrounding higher ground, the stream has been straightened, the thicket of small trees has been trimmed out and the unsightly place has been made equally attractive with the other surrounding grounds.

The fence on the south of the ponds above the highway for a distance of about twenty rods has been rebuilt, the tables used for picnickers have been removed and the grounds have since been in much better condition.

A connection has been made by a pipe connecting the windmill with one of the ponds, to furnish water for the windmill tank for fire protection, and for watering the lawns. Pipes for that purpose with taps have been laid to various parts of the grounds and the lawns have been kept in much better condition since these improvements were made.

The woodland lying on the sources of Cheney Creek and the Little Buckhorn, belonging to the State, joins the timber of adjoining private parties and it was thought advisable to define the boundaries to prevent cutting of timber on our premises. Forest fires were each year a menace to the standing timber and it was deemed desirable that this should be prevented as far as possible. We had our lines run out by a surveyor, and a force was put on to clear a strip of land along the line of the timber, rubbish and down timber along the boundaries, one rod in width. This was burned and last summer a board fence was constructed enclosing the property. A new fence has also been built along the frontage of the property on the Muskegon river.

Repairs have been made to the overseer's residence by putting on new double windows, repairing the cellar, and putting new wainscoting in the rooms on the first floor to render the dwelling more comfortable in winter.

The hatchery building has had a new floor put in the part not relaid two years ago. Four ventilators were built on the hatchery building to secure better ventilation. All the buildings on the property have been repainted, and minor repairs made.

Traps have been put in at the mouths of Cheney Creek and the Big Buckhorn and they have been housed in, for the capture of wild trout from the Muskegon.

The grove between the railway and the river has been fitted up for a picnic ground, with tables; a spring cleaned out for use of visitors and the grounds required for this purpose for the large number of visitors during the summer are now in excellent shape. This change of these grounds from immediately about the ponds has resulted in keeping the grounds free from the papers, broken food, and other accompanying things necessaryily connected with picnic parties which formerly kept the grounds littered with this material during the summer.

In the fall of 1895 and about the spawning time an epidemic disease attacked the parent brook trout, and there was a large mortality. The fish were attacked with a fungus growth and before the season was over we had a loss of between six and seven thousand spawning fish. We could assign no cause for the disease, but steps were taken to inquire into the trouble. The resulting loss has had the effect of somewhat reducing the output of fry from the station for the present year. Preventive measures have been taken to avoid a possible recurrence and we hope to avoid further losses. This disease is common to all pond reared fish.

Following the thefts of spawning fish in 1894, in the following spring we put on a permanent night watchman at this station. He was furnished with a time detector, which requires him to visit eight different stations at stated intervals during the night and we think the chances of further robberies have been thus minimized.

In the summer of 1895 the force at this station constructed a telephone line from the hatchery to the railroad station a mile distant. The poles were cut from the State property, and we now receive telephone notification of all telegrams from the agent and messages are transmitted in the same way, thus saving the time of employés and expenditure for messenger service for delivery of messages.

In July of 1896 serious fires on adjoining property threatened the buildings at the station with destruction. It was only by the most vigorous and untiring work that the threatened loss was averted. The whole of the regular force at the station and a volunteer force of the residents were employed for two days in arresting and extinguishing these fires. The lands immediately adjoining the State property is littered with old down timber, during the dry season of midsummer this is frequently carelessly fired, and until this has been removed from the land, which will only occur from decay, it will be a menace to the buildings on the hatchery grounds that will call for the greatest vigilance.

The grater portion of the timber needed in the improvements at Paris has been cut from trees on the premises by the force during the slack times in the summer. About 35,000 to 40,000 feet have thus been cut from our own lands the last two years.

There are now 23 ponds on the property, carrying about eleven thousand stock fish.

Floats have been made and put in the ponds during the past year to afford shelter and shade for the adult fish during the extreme heat of summer, and we believe with advantage to the fish. The ponds are unshaded by the foliage of trees, and the fish at times seem to suffer from the intense heat of the sun without protection of this nature.

SAULT STE. MARIE STATION.

ARCHIE BABBITT, OVERSEER.

The desirability of this place for a great commercial and game fish station has been emphasized by our experience here since the last report. Nowhere else, to our knowledge, are found conditions which promise and perform so much. At other places one kind of water of a certain temperature must be used for trout work, and another for whitefish and other commercial fish work. The same water will not answer for hatching both fish ordinarily. But here conditions are changed; here both of these fish live in this water as their natural habitat, and both operations can be successfully carried on at the same time. The place is an ideal one. Not only are brook trout and whitefish found native to the Sault river, but they are likewise common to Lake Superior, which, with its great depth and the purity and coldness of its water might be characterized as a mammoth spring.

Since the last report the new station, which had just then been built, has been equipped with the most modern appliances and methods within our knowledge and is today a model as a serviceable and complete hatchery.

The west end of the building has been fitted up with jar galleries and accommodates 200 Chase jars, supply tanks, foot tanks and storage tanks. The east end is fitted with eight banks of troughs containing three troughs in each bank, for the hatching of brook trout. In the arrangement of these troughs the regulation plan in use in the old hatcheries has been departed from to great advantage in the practical conduct of the work. Instead of being fed from a supply trough placed against the wall of the building, against which the ends of the banks or troughs are placed, and being fed from faucets or cocks from the main supply trough, under the new arrangement the hatching troughs stand entirely away from the walls of the building on the open floor space, and are fed by pipes coming from beneath the floor, the upper ends of which are curved or bent downward to near the surface of the water in each trough. This arrangement permits the free movement of the working force around either end of the troughs, and makes the labor much easier. The feed pipes to supply the troughs are out of sight underneath the floor, thus doing away with unsightly feed troughs and giving the freest movement in all directions about the floor space. Underneath the windows on each side of the house are arranged shallow picking troughs where this work is done under a good light.

The motive power for lifting the water is supplied by electricity, a dynamo, small pump and electric current having been furnished by the corporation of Sault Ste. Marie under the arrangement made with them when the location was fixed upon. The working of the dynamo and pump is nearly perfect, such difficulties as have presented themselves being of but small consequence and soon overcome.

Formerly when we occupied the experimental station at this place, a long and expensive drayage was necessary to transport the fish to the railway for distribution. At the time the new hatchery was built we were given to understand a spur would be built from the main line of the D. S. S. & A. Ry. to a point near the hatchery. This has been done since the last report was made, and our car can now be run to within about a thousand feet of the hatchery. The hatchery being on an island, no access can be had to it by teams, and it became necessary to make provision for transportation over this intervening space. We finally decided to construct a narrow guage electric railroad from the hatchery to the spur.

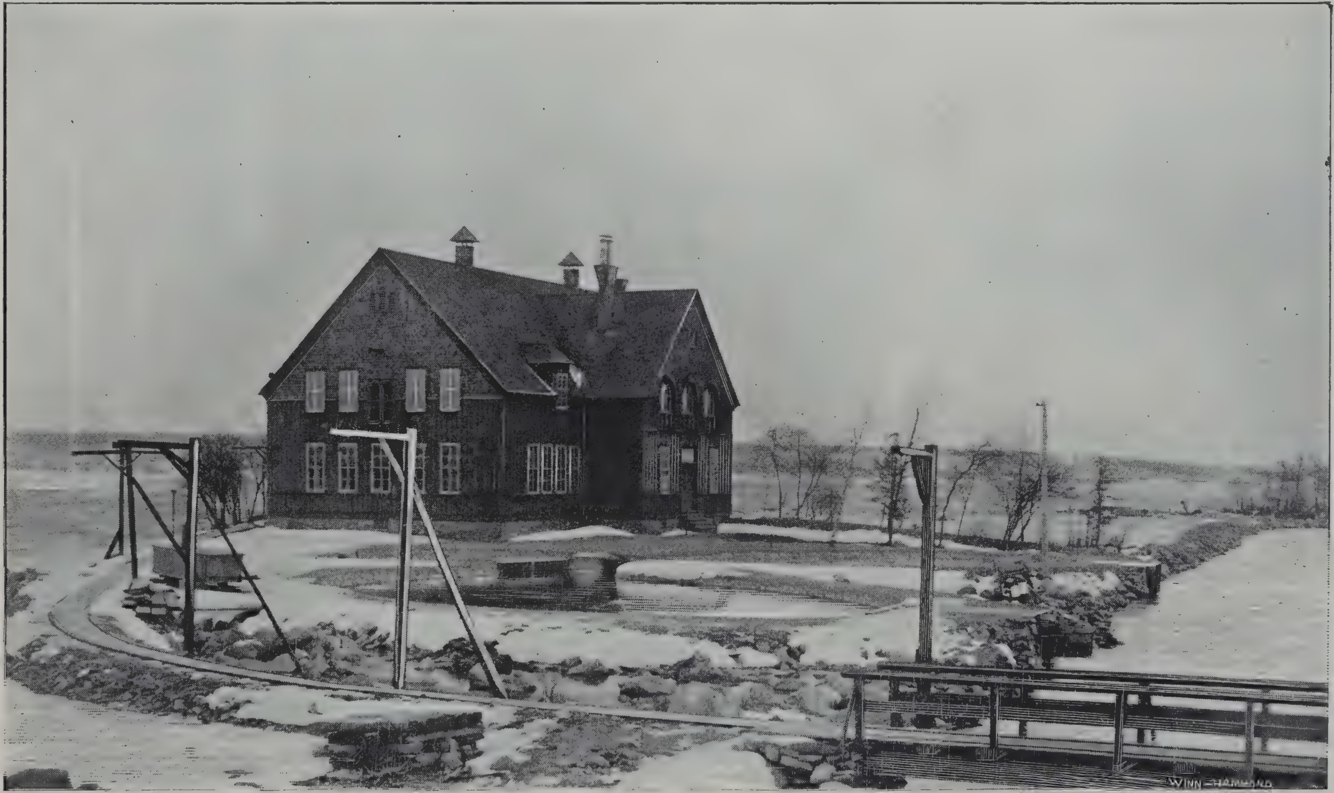
The contractors for the construction of the new lock, after the completion of their work had a large quantity of ties and rails, and through a favorable arrangement we were able to secure at a very reasonable price the necessary material to build the short railway from the door of the hatchery to the railway siding. We were also able to secure in the same manner timber for a bridge across the intervening channel. At a reasonable figure we also had built a trolley car to run over this tramway to transport the cans from the house to the railway spur, and the tramway is now in operation at a very low cost of construction.

During the summer of 1896 we cleared the ground immediately south and west of the hatchery of its boulders, with the aid of the trolley car and blocks and tackle as the motive power, and began the construction of three ponds in which to hold brook trout for stock purposes. Three fine ponds with connecting races and spawning race were completed in time to receive the fish before the spawning season began. The material with which the ponds were constructed is shaly stone mixed with soil, and it became apparent that it was not compact enough to hold a sufficient head of water in the ponds for our purposes. It therefore became necessary in order to put the ponds in proper shape to use water lime to make the retaining embankment. This made the work somewhat more expensive than we had expected, but when finished the ponds proved to be permanent in character and are in excellent condition.

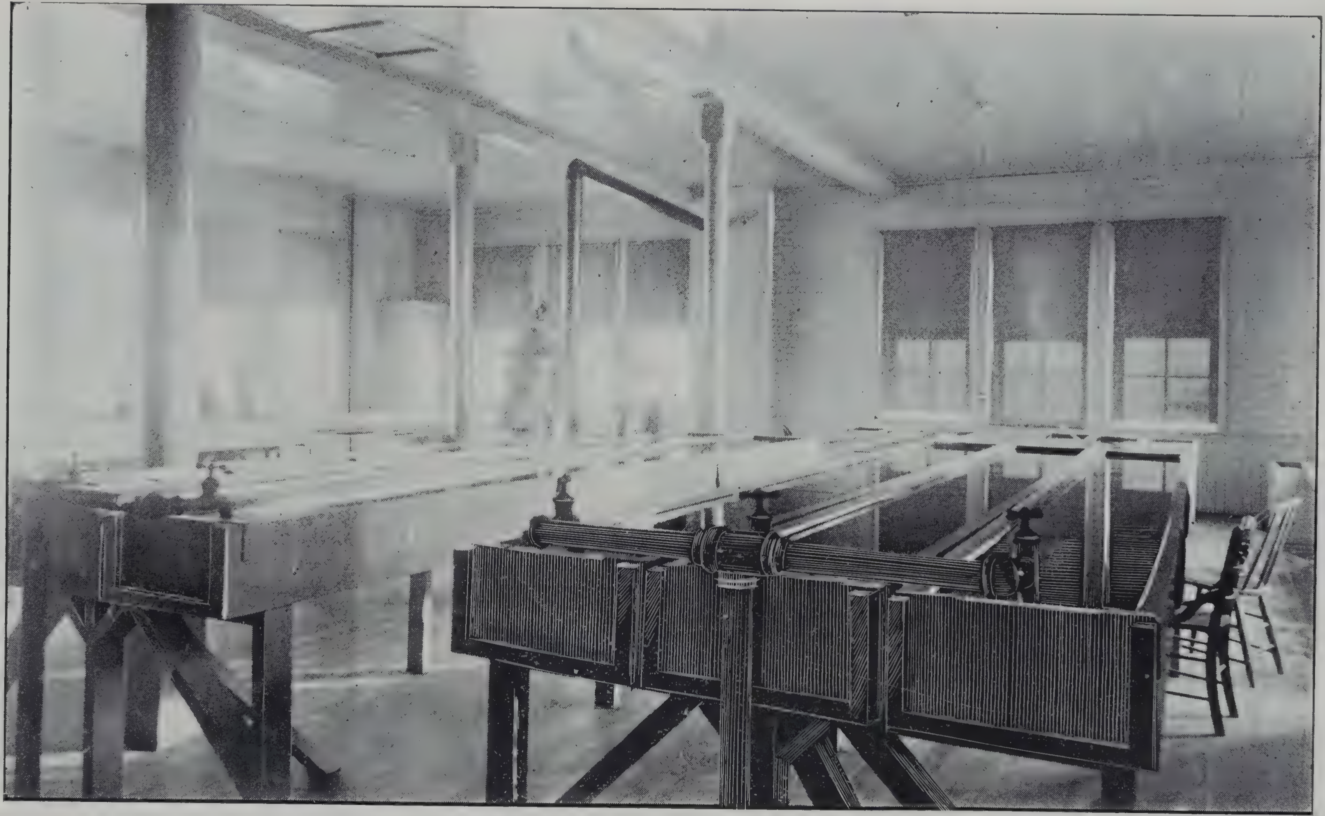
In these three ponds, which are of a clover leaf pattern, there were caught and placed last fall between 900 and 1,000 adult brook trout, from which were taken in the neighborhood of three hundred and seventy thousand ova.

Below the hatchery building we have a large area which can be made into ponds, and should be improved as rapidly as possible in order to bring this station to its full usefulness. To accomplish this, it will be necessary to turn the water that is now flowing over it away from this portion of the territory, and then carry on to this part of the premises a considerable quantity of soil with which to make embankments and ponds. This work, because of matters as they now stand, can be done much more cheaply during the coming summer than thereafter. The government now has on lands closely adjoining the hatchery a quantity of earth, excavated from the new canal lock, which must be removed the coming summer, to permit a grading and sodding of their grounds. We are satisfied arrangements could be made whereby this earth might be secured for our purposes if it is done this summer, and the cost would be comparatively small. Should this opportunity be allowed to pass, after the removal of that earth, the cost of getting the earth there would be greatly increased. It would have to be brought on scows for a long distance and then thrown off and loaded on to barrows and taken about twice the distance. This would greatly increase the cost of construction and would entail two more handlings of the earth, which is the main cost.

Then, too, the property we occupy is in the heart of the Government Canal Reserve. During the coming year the authorities contemplate grading and arranging the grounds immediately adjoining the canal, under a general parking plan for their beautification. When the right was given the board to occupy the place free of cost, as a site for a hatchery, it was understood that the State would put the grounds into such shape as would conform to the government's parking plan, and it would practically become, by reason of its situation, a part of a handsome public park. This work must be done at some time, and can be done better and more economically now than ever again, and we ask that a sufficient amount be allowed to complete the work the coming season. When this station is completed, the ground graded and sodded, and the plant completed, it will be able to care for the waters of the Upper Peninsula and will be one of the stations in which our people will justly take pride.

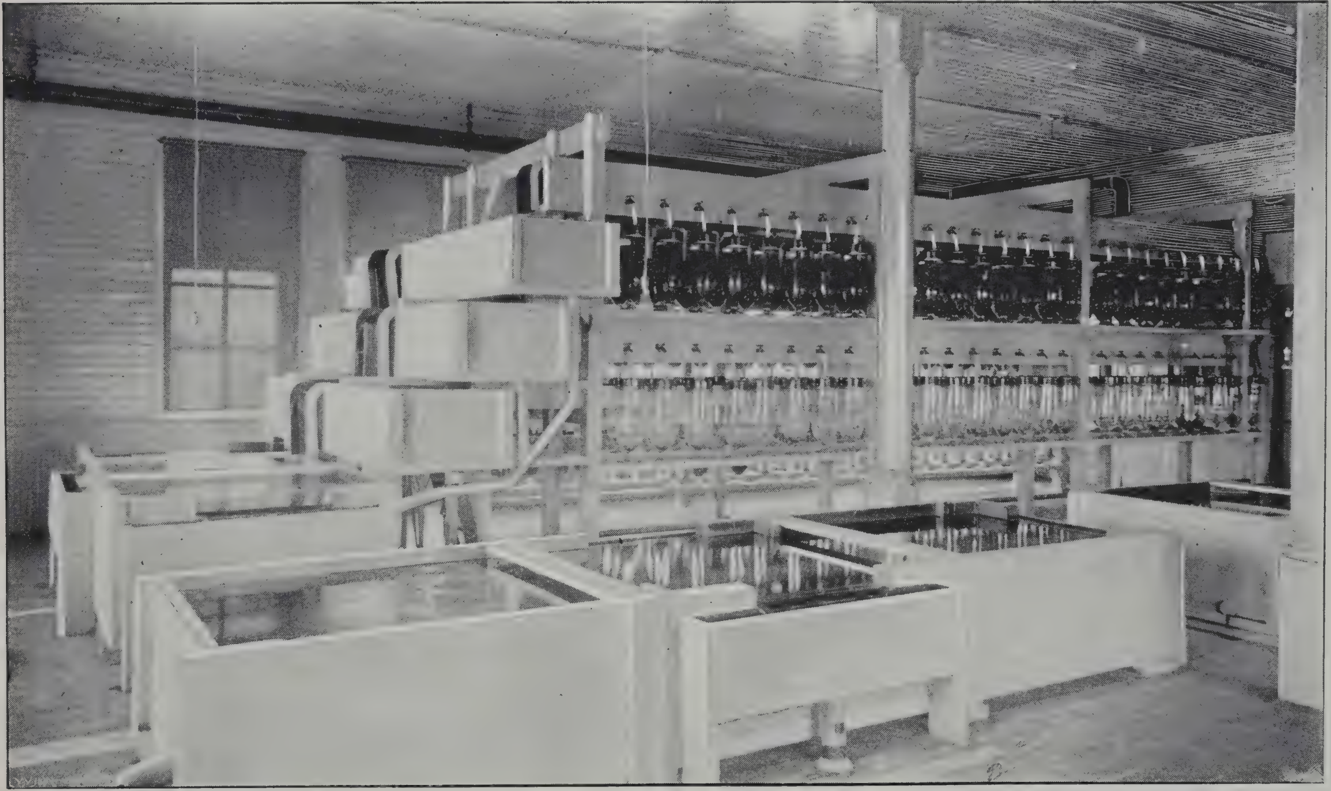


SAULT STE. MARIE HATCHERY.
PONDS AND ELECTRIC RAILWAY.



VIEW OF INTERIOR OF SAULT STE. MARIE HATCHERY.

TROUT TROUGHS.



VIEW OF INTERIOR OF SAULT STE. MARIE HATCHERY.

WHITEFISH JARS AND TANKS.

CASCADE STATION AND BLACK BASS WORK.

CHAS. HOLT, OVERSEER.

In 1893 a station was established on grounds at Cascade in Kent county, for the purpose of conducting experiments in the breeding of small mouthed black bass for distribution in our inland lakes, many of which from years of continued fishing of all kinds had begun to show a decay of the natural stock.

There is hardly a game fish in America so widely distributed as this fish. Its range is from Florida far up into British possessions, and from the Atlantic to the Mississippi, with the exception of a few circumscribed areas. For gaminess it easily takes first place, and in edible qualities is deservedly popular.

The people of Michigan, "The Land of the Lakes," have always had a high appreciation of the bass. The great majority of our beautiful inland lakes have at one time or another abounded with this excellent fish. With acumulation of wealth our people have found more time for leisure and recreation and about the shores of hundreds of these rural gems have sprung up resorts and summer cottages where the people take their summer outings, and angle for the bass. The constant drain upon these lakes has created a demand upon the commission for young bass with which the wasted stocks may be replenished, until now these demands have far outgrown our small ability to satisfy them.

Until 1893 we had never undertaken to propagate bass, nor had the experience of other fish culturists in their artificial propagation been such as to serve as an aid in determining the practicability of such operation. Under these circumstances we did not feel justified in incurring much expense in carrying on our experiments, beyond what was actually necessary to determine what could be done with bass under domestication. When held in confinement certain animals are so influencd by their surroundings that they absolutely refrain from the exercise of the function of reproduction, and this is true of certain fishes.

The salmonoids have always proven most tractable, and the ease with which the artificial fertilization of the ova of this variety of fish as a rule is accomplished is proverbial. On the contrary, many of the spiny rayed spring spawning fishes prove intractable and but shall success results from such operations. So without the knowledge derived from actual experience in breeding bass we were somewhat at sea.

Our earlier attempts to handle these fish and artificially imprĕgnate the ova led to the belief that it might be successful. Our added experience, however, has convinced us that, considering the natural peculiarities of the bass, and the good results obtained, a much larger success, at less expense will result by carrying on the hatching by the pond-culture system.

With a small number of fish carried in two small ponds for three years we have achieved excellent results. These operations have been carried on under the disadvantages of a poor water supply, and we have been handicapped in other ways, but we have in the past two years distributed from two ponds containing about 100 adult fish 194,800 bass. This has been supplemented by 135,000 taken from the natural beds in the Thornapple, and by 164,000 large mouthed bass taken from a small neighboring lake.

The fact that we were distributing black bass has become known and the requests from all quarters for young fish have absolutely overwhelmed our feeble capacity to respond to these calls. Believing that this growing demand should be satisfied, and knowing that no branch of our work would be more fully appreciated, the board has carefully investigated in the last year about half a dozen possible locations for the establishment of a bass station. Most of these places had suitable water, but the things most desirable, good water and convenient railroad facilities for shipment, without large expense for transportation from ponds to car were found at none of the places except on Plumbs Creek in Kent county. Here is an ample volume of water, the land necessary for the station is fairly reasonable in price, and excellent facilities for cheap shipment is assured. Five acres of land have been secured here upon which can be constructedthe necessary ponds, and within a year we should be able to distribute five hundred thousand bass from the new station to the inland lakes, and in another year we should be able to double that amount, and gradually increase the quantity far beyond that capacity.

It will be necessary at this session of the legislature to provide a sufficient money to dam the stream above the proposed site to give head for a supply for the ponds, to lay the pump logs for carrying the necessary water, construct the ponds and required races, and build a small dwelling for the resident overseer, a tool house, and to provide for the necessary grading and fencing of the grounds.

GLENWOOD.

WORDEN WELLS, OVERSEER.

This station has been run on the same basis for a number of years, and is the station from which carp and gold fish are sent out.

The carp has proven a valuable fish for the people who buy the cheaper varieties. The carp is a rapid grower and attains to a large size. It is suited to many of our large ponds and lakes in which other fish are not found, and large quantities of carp are sold in the State each year.

The fish is well suited to pond culture, and when cared for and fed well repays for its culture. In New Jersey and in some of the other eastern states, the raising of carp for market is carried on quite extensively by private parties with profit. The cary does not rank with our finer varieties of fish, but is quite superior to any of the sucker family or the grass pike, thousands of pounds of which are marketed every year.

The board have in the last year discontinued the rearing of gold fish at this station, as being outside our province, it being a purely ornamental fish. Beyond a few that are given to municipalities for ponds in parks, nothing is now done with this fish by the board.

CHARLEVOIX STATION.

J. P. MARKS, OVERSEER.

This station is still run as a relief station for the hatching of eyed whitefish ova, and it is only run for about two and a half or three months of the year. When the ova has sufficiently developed in the Detroit hatchery, the quantity designed for distribution in Lake Michigan and in the Straits of Mackinaw are sent to Charlevoix, where the hatching is completed. In actual operation this station has been of great service. It serves as a relief to the Detroit station which before the establishment of this station was often filled during the latter part of the hatching season with young fish to such an extent that it was beyond the capacity of two cars kept in constant employment to free the house of fish and keep them in good condition.

The building occupied at this place is rented, and was put in condition for the service required of it at a small cost. It is in charge of one of the regular employés of the board during the time it is in commission, and is run at a low cost of management. No improvements have been made here during the last biennial period, beyond the small repairs necessary to keep it in condition.

Eventually it would be well for the State to build at this point a permanent hatching station for the hatching of lake trout. Charlevoix is the most important point for the taking of lake trout in the State, and if this fish is to be maintained early attention will have to be given to its propagation and distribution. Such a station may be built here at a very moderate sum, if the municipality of Charlevoix will consent to grant to the commission a free site and a perpetual water supply.

THE CAR.

H. H. MARKS, CAPTAIN.

The car "Attikumaig" has continued to give most effective service in the distribution of fish. It is constantly in commission from about the first of February to the end of July in each year, and makes an annual mileage of between twenty and thirty thousand miles. This includes the distribution of trout of different kinds, whitefish, wall-eyed pike, carp and black bass.

The establishment of the station at Charlevoix has relieved the car of a large amount of work, and were it not for this the service of another car would be required.

It has been necessary to make far more extensive repairs to the car than were contemplated two years ago, and the estimate for this purpose was considerably below what has been actually spent. With the heavy loads carried and with the constant use to which it is subjected, it is only a question of a short time before a new car will have to be purchased.

A year ago last fall it was run to the shops and given a thorough overhauling and repaired at a cost of about $1,400. On the first trip made with it afterwards, when carrying 21,000,000 whitefish ova to Charlevoix, during one of the severest nights of the winter, she was thrown from the track by the misplacing of a switch at Traverse City and badly wrecked. All her cargo was lost on account of the severity of the weather, and the crew were badly shaken up, but not seriously injured.

The C. & W. M. Ry., who, through an employé's fault, were responsible for the disaster, immediately ran the car to their shops and put her in as good condition as possible. It appeared to be as good as ever, but later on it became evident that it had been weakened. It has since been necessary to make other repairs to keep it in condition.

When we consider the large mileage the car runs in a year, and the length of time it has been in service, we must admit it is now in better condition than might be expected. With the many thousand miles it has run this is the only mishap it has had of a serious nature.

It seems quite desirable, in order to carry fish with minimum chances of loss, particularly adult fish, during the summer months, from field stations where men are engaged in capture of wild trout for new stock at the different stations, that a plant should be placed in the car by which air can be forced into the receptacles in which fish are carried. The present method mainly used by us to secure safety in carriage of fish is refrigeration, that is, the temperature is lowered by the introduction of ice into the water, as well as about the cans. This renders the fish measurably dormant and their consumption of oxygen is smaller for this reason. But there is more or less danger in this method, the water sometimes becoming robbed of the necessary amount of oxygen to sustain the fish. There is an additional danger if the utmost care is not used, in changing them to water of a greatly different temperature at the end of the journey.

By the installation of a proper plant permanently in the car, fresh air can be forced into the water in which the fish are carried and the danger minimized to the lowest point. We have made some investigations as to the cost of such a plant, and find that it can be put in at a cost of probably about five hundred dollars. We would ask that a sufficient amount be allowed for this purpose. Once in working order, it will greatly improve our present method, especially in the handling of adult fish in hot weather.

COURTESIES AND EXCHANGES.

We desire to acknowledge the receipt of 35,000 black spotted trout donated by the U. S. Fish Commission from the Leadville hatchery. This fish is a native of Colorado streams and is esteemed as a good game fish. It is said to grow more rapidly and to a larger size than the brook trout or rainbow. When hatched and ready for distribution, these fish were placed in the Pere Marquette and Little Manistee rivers. The plants were made in fewer streams than they otherwise would have been, in order to get earlier results, and that we might thus learn as soon as possible how this new fish would thrive in our waters. Should he do well, these plants can be hereafter supplemented with others and be given a more widespread distribution.

We also received from the same source 481 gold fish and 150 adult brown trout, which were planted in wild streams and donated to applicants.

The New York Fish Commission in January, 1895, donated 50 adult female rainbow trout, 100 yearling rainbow trout and 100 yearling brown trout.

The thanks of the board are due to the Canadian authorities for granting permits to this board to take ova of the brook trout and salmon trout in their waters, under the condition, voluntarily given, that we would return a good plant of young fish when hatched to the water from which they were taken.

An exchange of 100,000 eyed ova of brook trout from the Sault station was made with the Castalia, Ohio, Fishing Club, for an equal quantity of trout ova from that station.

We desire to acknowledge the courtesy extended by Mr. Wheeler, superintendent in charge of the Sault canal and improvements, and to Hon. Andrew Jackson, for donations of gravid female brook trout during the fall of 1896, from the fountain at the locks and from private aquaria, which were a material addition to our small stock of spawning fish at that station.

STATISTICAL AGENT'S REPORT.

Detroit, December 31, 1896.

To the State Board of Fish Commissioners—Having completed the canvass of the commercial fisheries of the State and the compilation of the statistics under your direction, I herewith submit a narrative statement of their condition for the years 1894 and 1895.

For convenience in making comparisons, conducting and tabulating the work, the lake coast of the State was divided into five districts in 1892, which are as follows:

1st district includes the Detroit river from Detroit to Lake Erie, and all of Lake Erie lying within the State.

2d district, the east shore of Lake Michigan lying within the State, the Fox and Manitou Islands, the Straits of Mackinaw and the north portion of Lake Huron as far south as Rogers City.

3d district, the north shore of Lake Michigan lying within the State, including Green Bay, the Beaver Island group and the north shore of Lake Huron to Detour.

4th district, the west shore of Lake Huron from Rogers City to Port Huron, including the St. Clair river, Lake St. Clair and Detroit river to Detroit.

5th district, all of Lake Superior lying within the State, Isle Royal and Sault Ste. Marie to Detour.

DISTRICT NO. 1.

The waters of this district being shoal, the fishing is carried on almost entirely with pound and fyke nets, a few gill nets being fished from Monroe. The catch consists largely of rough fish, perch, suckers, carp, etc., although of the better kinds of fish a good many wall-eyed pike are taken, also a few sturgeon and whitefish, the annual catch varying with the seasons, as shown in the following table:

In this district, I have to note an annual increase of the German carp, which are prolific and of rapid growth. The grounds about Monroe being so well adapted to them, it is the opinion of the fishermen in that locality that other kinds will gradually disappear and that they will compose the principal part of their catch in the near future. The commercial value of the carp is from one-half cent to three cents per pound in the round; governed by market conditions, as are all other kinds of fish. Some of these fish attain a weight of twenty-five pounds each. One of the most profitable fish caught in this district, the sturgeon, are falling off each year, with little hope of restoration.

Whitefish were at one time very abundant in this district, but have been fished out until the catches had become very small compared with former years, but since the planting of whitefish fry began they have been partially restored. The catch of whitefish in this district in 1895 was 45 per cent better than that of 1893. There appears to be no feeding grounds for the young whitefish in the west end of Lake Erie, at least I find very few are caught in the pound nets fished there during the summer.

The catch of pike, perch or wall-eyed pike in this district for the year 1895 was nearly double that of any of the four preceding years, thus showing that they withstand the continued fishing of these waters better than any of the more valuable kinds of fish. The total product of the fisheries of this district for the year 1895 was something over 1,500,000 pounds. Of this catch, 104,000 pounds were whitefish, reported as being adult fish; 429,000 pounds of wall-eyed pike, 226,000 pounds of German carp, the balance being made up of other kinds, largely suckers and perch.

DISTRICT NO. 2.

This district embraces an extensive lake coast and presents some features of the industry not found in the first district, most prominent of which is a kind of fish termed by the fishermen of that locality long jaws. While they are essentially a deep water fish their general appearance, the decided protrusion of the under jaw and their size indicate that without doubt they belong to the herring family. They are chiefly caught in forty to seventy fathoms of water with large gangs of gill nets fished with steam tugs, from St. Joseph and Grand Haven, two of the largest fishing stations in this district. When put upon the fresh fish markets for sale, they are dressed the same as the whitefish and trout and their price to the fishermen for the past two years has been from two to two and one-half cents per pound. To a considerable portion of this catch, however, these prices do not apply, as many tons of them are sold at a less price to smokers, being too small to ship fresh.

And here I have to note the yearly decrease in the catch in number of fish at these places since 1893—as well as the rapid decrease in pounds. In 1891 the gill nets in general use by the fishermen of this district for the catch of long jaws were of three-inch mesh and they were continued in use, with perhaps a few exceptions, till 1893, when a reduction of the meshes began, and in 1895 a 2½-inch mesh net was in general use. The size of the mesh tells what the size and character of the fish is, and the following figures for each of the years referred to will show the devastation such destructive methods have brought to the fisheries of this district.

For the year 1893 the catch of this kind was 4,297,725 pounds; 1894, 2,455,850 pounds; 1895, 1,649,933 pounds. Showing the annual decrease to be nearly one and a half million pounds. They are a cheap fish, and are of much less importance than the whitefish and trout which compose the largest portion of the catch in this district, and by far the most valuable part.

During the same period the whitefish and trout suffered a marked decline, but it has not been quite as rapid; the causes, however, have been the same, namely, the fishing of small mesh twine in both the gill and pound nets which are extensively used in this district. Large outfits of gill nets are fished from St. Joseph, Grand Haven, Manistee, Frankfort, Charlevoix and other smaller stations along the shore, and pound nets along the shores in waters adapted to them. The constant fishing for lake trout at all seasons of the year, which is true of the south end of this district, when the winters are mild and the harbors are open, together with the taking of young trout with small mesh gill nets used in fishing for long jaws and blackfins, no doubt has had much to do in depleting these waters of the lake trout.

In 1893 the catch of lake trout of this district was 2,498,400 pounds; in 1894, 2,045,900 pounds; in 1895, 1,734,350 pounds; showing an annual decrease of nearly one-half million pounds.

In speaking of the whitefish catch of this district and referring to the causes that have led up to its decline, the reasons herein given have been gleaned from personal investigations, and apply with equal force to the whitefish grounds all over the great lakes. In considering the different varieties of fish of these vast bodies of fresh water, in commercial importance the whitefish takes precedence over them all, therefore their destruction is of much greater significance. At one time they were most plentiful in all these great lakes, so peculiarly adapted to them, and continued so until the introduction of the pound net. Some years ago this device came into general use by the fishermen, not only of this district, but throughout the entire chain of lakes, and very soon after its advent came the rapid destruction of the whitefish. So well adapted are these nets to their capture, from the fact that the fish go in schools and are good leaders, they are easily taken. The mesh of the pots in pound nets now in general use are so small that when the fish are once in the pound their escape is impossible. From personal observation and the statements of fishermen themselves tons of little whitefish have been thrown upon the shores, too small for any use except for fertilizing purposes. The inevitable conclusion is that this mode of fishing is one of the most potent causes of their gradual extermination from these waters. The good results obtained from their planting, which the fishermen themselves endorse in strong terms, are to a very great degree neutralized by the wasteful methods of fishing practiced.

In this district the catch of whitefish for the year 1893 was 1,158,500 pounds; 1894, 953,705 pounds; in 1895, 603,490 pounds; showing a large annual decrease, and for the years 1894 and 1895, one-half million pounds of these were immature fish, chiefly No. 3's and under.

The sturgeon, now a most valuable fish, and very abundant at one time in this district have also suffered a great decline, and being of slow growth the capture of the immature fish (which might easily be returned to the waters alive when taken and in all cases should be) means an earlier destruction of the sturgeon than perhaps any other valuable fish in this district.

DISTRICT NO. 3.

This district embraces the north shore of Lake Michigan and the Beaver Island group, and the extent of its lake coast is about only one-half that of the second district. The general features of the industry, however, and the appliances used in fishing are the same, and the value of its products are nearly equal to that of the second district. The largest catch of any one kind of fish in this district are the shoal herring that are taken in Green Bay from Menominee north on the shore a distance of fifty miles, where fifty-two pounds nets are fished with an annual production of over two million pounds, and at Gros Cap, between Pt. Aux Chenes and Pt. St. Ignace. The shoal herring leads in the catch of the third district, and the deep water herring in that of the second district.

In Green Bay there has been a slight increase in pounds of the herring catch for the past three years, but there has also been a marked decrease in their size, owing to the small mesh used in the pounds of the nets fished upon those grounds.

The Menominee, a mongrel whitefish, ranking in value somewhat better than the herring, are caught in Green Bay and down the shore of this district with gill nets in considerable quantities, and are becoming quite a factor in the gill net catch. They are used exclusively for salting, being a soft fish, are of larger size than the herring, and more valuable. The reduction of the mesh from 3¼ to 2½ inches is having a serious effect upon them also.

Wall-eyed pike, which are always found in greater abundance in large rivers, or in bays where such rivers have their outlets, are chiefly caught in this district in Big and Little Bay De Noquette, and constitute by far the largest and most profitable portion of the catch in that locality, and the quality of the fish caught here is excelled nowhere upon the entire chain of lakes.

The sturgeon catch of this district is about the same as that of the second, and the persistency of the fishermen in taking the small sturgeon is showing its effect.

Last, but not least, attention is called to the whitefish and trout catch of this district. While the catch of these varieties is considerably less in pounds, their commercial value is equal to the combined catch of all the other kinds put together. The decrease in the catch of lake trout here is marked, but it has not been as great as in the second district. In 1894 the catch was 993,945 pounds, and in 1895 was 768,150 pounds, which shows a falling off of one-quarter million pounds. From information gathered from the fishermen, whose experience goes back a quarter of a century or more, the whitefish grounds of Green Bay and the entire shore of Lake Michigan lying within this district, together with the shoals and reefs included therein, are the best adapted to this fish, and have been the most productive of this most valuable kind of fish of any waters lying within the State. Owing to the methods of fishing with pound nets, which are the same as those referred to in the second district, and to the vast amount of sawdust and mill offal carried out of the Manistique river, covers the bottom of the lake for miles in every direction, there has been an annual decrease since 1893 of over 340,000 pounds.

In 1893 the whitefish catch of this district was 1,296,450 pounds; in 1894, 742,800 pounds; in 1895, 616,160 pounds—550,000 pounds of the last two years' catch, which is nearly one-half, consisted of 2's and 3's, many of them being of the herring grade. Just so long as this method of taking the young whitefish is permitted, just so long will the whitefish surely and gradually disappear and the work of planting be robbed of its results.

DISTRICT NO. 4.

The extent of coast embraced in this district is about the same as that of the second, but some of the features presented differ from those of any of the other districts. The appliances used in taking fish are the same, except that in the waters of Saginaw bay and Saginaw river, which are shoal, a vast number of fyke nets are fished. They are used and operated, however, upon the same principle as the pound nets, having leads and hearts and a bag or pound. From Rogers City to, and including Au Sable, pound nets are fished at some of the stations, but by far the larger portion of the catch is made with gill nets and consists chiefly of whitefish and trout, fully three-fourths of the catch being lake trout.

The fisheries of Saginaw bay and Saginaw river, inside of a line drawn from Au Sable Point to Pt. Aux Barques, in 1894, produced in the aggregate 9,834,271 pounds of fish, and the outfits used in their capture were nearly all pound and fyke nets, the total number used being about five hundred. Of this catch, about two million pounds were whitefish, trout and wall-eyed pike; the balance were chiefly rough fish of small market value. The local laws now in effect prohibiting the catch of small fish of the various kinds in this locality, with a good enforcement of the same, would be of great benefit to the wall-eyed pike, but none whatever to the young whitefish, as it does not apply to the fishing grounds where they are taken.

From Port Austin to Port Huron, pound nets, gill nets and seines are used by the fishermen, the catch consisting of whitefish, lake trout, sturgeon and herring. Near the outlet of Lake Huron at Fort Gratiot, more sturgeon are caught than at any other place in the State, and their yearly decrease in this district is quite as pronounced as that of any of the others. The fishing from Port Huron to Detroit, which completes the review of the fisheries of this district, is carried on with hook and line and seines in the St. Clair river, and pound nets and seines in Lake St. Clair and Detroit river, the product of the catch being wall-eyed pike, whitefish, and a considerable portion of rough fish. The baneful effects of pound net fishing in this district upon the whitefish is shown, 40 per cent of the catch being 2's and 3's and under.

DISTRICT NO. 5.

This district embraces the entire coast of Lake Superior lying within the borders of the State, Isle Royal and the Sault river, to Detour, at the head of Lake Huron. It is the largest of any of the subdivisions, and the catch of whitefish and trout is largely in excess of that of any of the other districts. The manner of fishing these waters and the appliances used in the capture of fish are the same as elsewhere adopted by the fishermen; the catch consisting of whitefish, trout, pike perch, herring and sturgeon, and in the order above named as to quantity and marketable value.

The trout catch of Lake Superior consists chiefly of the siskowet variety, which is not as well adapted to the fresh fish markets as the Mackinaw or shoal water trout, being too fat; but when salted, it finds a ready market.

Throughout this district pound nets, gill nets and seines are fished upon the grounds best adapted to each of these devices, and the kinds of fish taken have already been enumerated. Pound nets are fished from the following stations in this district, viz.: Union Bay, Ontonagon, at the outlets of the Flint Steel, Fire Steel and Sleeping rivers, Eagle Harbor, Copper Harbor, Bete Grise bay, Traverse bay, Portage entry, Fewsville, Catholic Mission, Baraga, L'Anse, Huron bay, Big bay, Marquette, Au Train, Old Munising, Grand Marais, Whitefish Point, Whitefish bay, the Sault river and Detour. At many of the above stations gill nets are also fished, but principally from Isle Royal, Ontonagon, Portage Entry, Marquette, Grand Marais, Whitefish point and Detour.

Each year since 1891 there has been a marked decrease in the catch of whitefish and trout in this district, but the depletion of whitefish has been much greater than that of the trout, as shown by the following data. In 1891 the catch of trout was 3,772,500 pounds; that of 1895 was 2,555,615 pounds, which made the falling off of trout during that period 1,216,885 pounds. The whitefish catch of 1891 was 4,819,900 pounds, and in 1895, 1,717,220 pounds, showing the decrease of the whitefish during that same period to have been 3,102,680 pounds, or nearly three times greater than that of the trout.

Of the 1,717,220 pounds of whitefish caught in this district in the year 1895, 470,000 pounds were immature fish and every ground in this district fished with pounds nets furnished a portion of this amount of small whitefish in greater or less quantities, but more notably so at Marquette and Detour, where liberal plants of whitefish have been made during the past five years. In this district, as well as in the others, the use of the pound net is the chief device, in the destruction of the young whitefish. The herring caught in this district are principally taken at the Calumet water works, Portage Entry and Marquette. They are of little importance, however, as the total catch for the year 1895 was only 207,000 pounds.

At all of the above stations small whitefish are taken and the fishermen in reporting their annual catches, put them in under the guise of herring. This is especially true of the reports taken at Marquette and is amply verified by some of the fishermen at that station.

The catch of immature fish and the wasteful manner of fishing practiced by the fishermen throughout Michigan's entire lake coast, especially where pound nets are fished, is a matter of great concern, and is doing more than any other one thing to entirely deplete the great lakes of whitefish, and must ultimately ruin the fisheries of our State. For example: At Mackinaw City in July, 1895, sixteen packages (or half barrels) of salt whitefish caught with pound nets a few miles below, were brought there and sold. Opening a package for inspection, we took out eight fish and put them on the scales, and the eight fish weighed only one pound. This showed that the package contained 800 fish that netted the fishermen only seventy-five (75) cents! Could these fish have remained in the lake two years, they would have attained a weight of at least one and a half pounds each, and the 800 fish would have weighed 1,200 pounds. At four cents per pound they would have brought the fishermen $48.00 as against 75 cents.

In July, 1896, at this same fish house at Mackinaw City, the entire catch of a pound net fisherman a few miles above, for the months of June and July of that year, was brought by this firm and an examination of their books disclosed the following fact: Total catch eighty-nine (89) packages of salt fish. On inspection they were graded as follows: 60 packages No. 3 white; 19 of No. 2 white; 3 of No. 1 white, 4 of herring, 2 of suckers and 1 of trout.

The commercial fisheries of the State, extending over a lake coast of two thousand miles, employ about five thousand men, with an annual production of 37,000,000 pounds of fish food, that brings to the fishermen each year over $1,000,000, makes it a most valuable industry; an industry that should be fostered by the State, both by the liberal appropriation of funds for the artificial propagation of fish with which to stock the waters of the great lakes, and by the passage of good and wholesome laws, with a thorough and efficient enforcement of the same for the protection of the young whitefish, also the adult fish during their spawning season.

Respectfully,
C. H. Moore,
Statistical Agent.

In connection with the foregoing report the following diagrams are published to emphasize the fact:

Diagram showing decrease in pounds of whitefish caught in Michigan waters in 1885, 1891, 1892, 1893, 1894 and 1895.

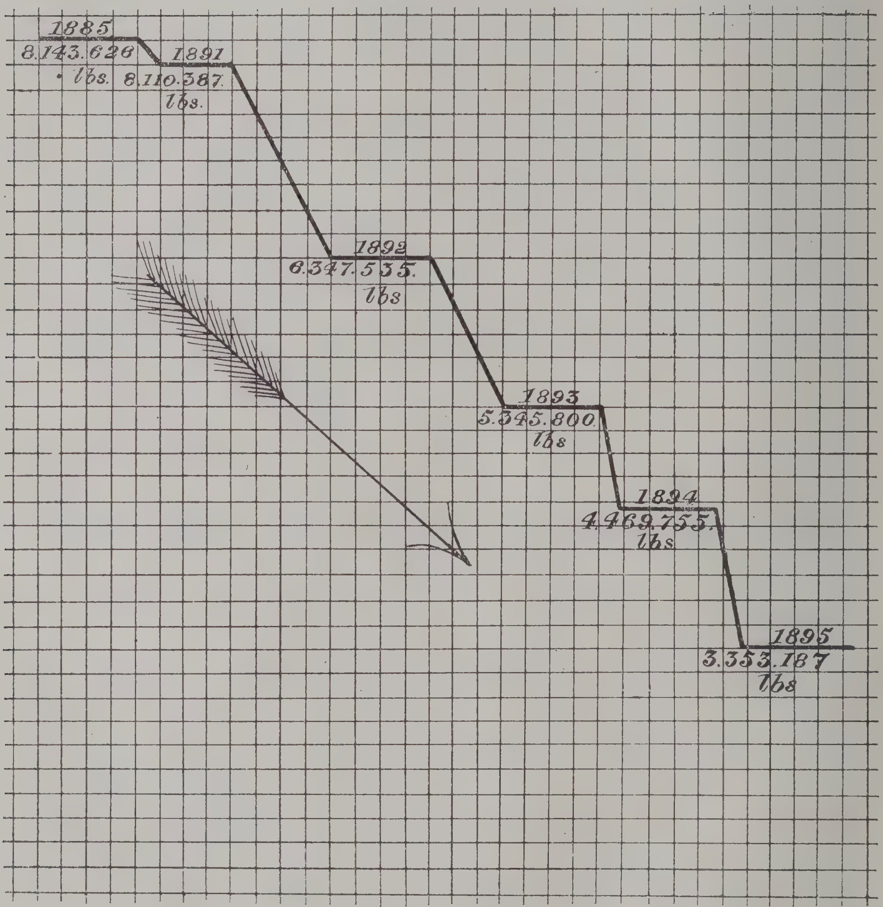


Diagram showing decrease in pounds of lake trout caught in Michigan waters in 1891, 1892, 1893, 1894, 1895.

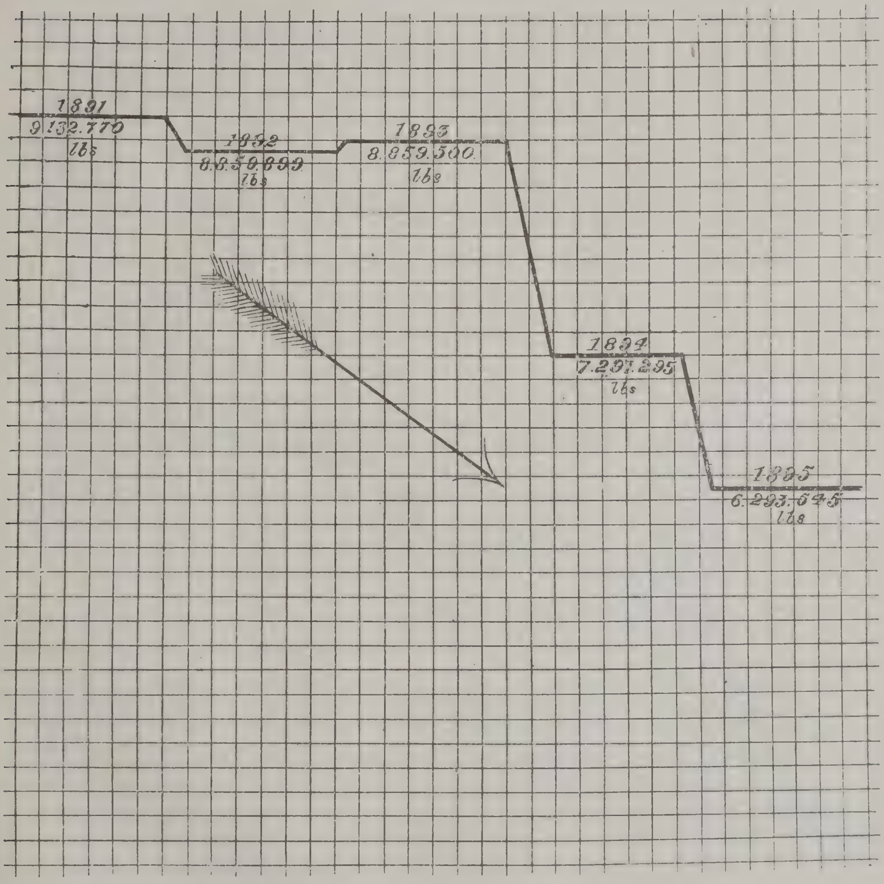
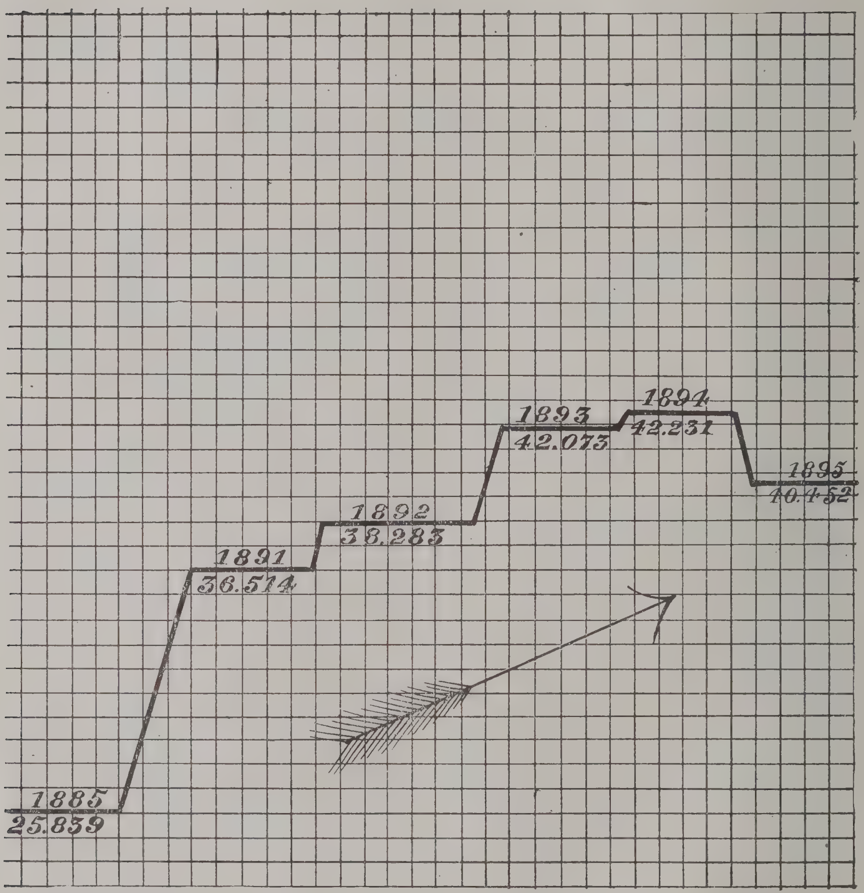


Diagram showing increase in number of nets used in Michigan waters in 1885, 1891, 1892, 1893, 1894 and 1895.



LETTERS OF COMMERCIAL FISHERMEN.

ON THE DECAY OF THE FISHERIES AND CAUSES, AND THE SUCCESS OF ARTIFICIAL PROPAGATION OF FISH.

Escanaba, Mich., *Dec. 5, 1896.*

Your letter at hand and noted. In reply will say that we noticed more small whitefish were caught here last summer and the summer before than in the seasons previous thereto, and furthermore, that those small whitefish indicate by appearances that they are planted fish.

Respectfully yours,
HANSON & JENSON.

Marquette, Mich., *Dec. 10, 1896.*

Kindly note enclosed item, taken from Daily Mining Journal published in town here. Item is self explanatory. I am sure you can agree with me that this would be very injurious to fishing here, especially for whitefish, if it is carried through. These people have been catching young whitefish for herring pretty nearly all season until law was enforced recently. Kindly do what you can to stop this, as it is no use planting whitefish here and having them caught and sold for herring. Kindly send me a copy of fish and game laws for reference.

Yours truly,
JOHN PARKER.

Bay City, Mich., *Dec. 4, 1896.*

Your letter received. Have been very busy and no time to answer the question asked.

Now all I can say is this, that while the planting of whitefish in my opinion would be very beneficial, it has not been allowed to show itself, as unscrupulous and ignorant parties have caught and salted too many small ones. That a great many small fish have been taken is very evident to yourself and the greatest wonder is that even a small percentage of these fish that visit the feeding grounds ever attain the size they do.

I should say keep on planting fish, but for heaven's sake do stop the catch of small ones by strict laws duly enforced.

Yours truly,
D. A. TROMPOUR.

AU SABLE, MICH., *Dec. 4, 1896.*

Mr. C. H. Moore:

DEAR SIR—Yours to hand several days ago and in reply must say that Mr. Whitaker's letter or communication in the press of this date voices my sentiments in regard to Mr. S. H. Davis, and in fact nearly all the large fish dealers are in the same boat—all self.

Now, Mr. Moore, there is one thing I would like to impress on your mind and that is, whatever laws you people make or cause to be made, you want to regulate the size of mesh in trap nets and gill nets, but don't be led away with the idea that the size of the fish, say one and one-half pounds, would stop the catching of small fish not in the least, for, as a matter of fact, if the mesh was ten inches, we would often catch small fish. Then what would you do with the small fish? Would you throw them away, or what would you do with them?

You can rest assured that I am at your service at any time and all times to give you all the information I can, but don't make laws that a man will have to break or else go out of business. Make the mesh whatever size you like, but have the good sense to leave the weight alone, because we can and do, and can't help but catch some small whitefish and trout in our gill nets, and Davis, Alpern, and all the rest know it full as well as I do, but the amount is small. But look to the trap nets. That is where your small whitefish are murdered.

Yours respectfully,
D. LINCOLN.

THOMPSON, MICH., *Dec. 11, 1896.*

As I understand, there is a scheme to do away with the State hatcheries. Now, I think that would be the worst thing that could be done to the fishing business, for I am a fisherman and have been at the business for twenty years, and know that before there were any fish planted on the grounds at Bark Point and vicinity, there were hardly any fish to be got; could not make it pay to fish for them, but since fish have been planted we are having a good increase every year. This year our catch was nearly double what it was last season.

Now, I will close by saying I hope that the State will continue to hatch and plant fish until it will be up to what it used to be in the fishing business.

Yours truly,
SIMON J. BOUSCHOR.

EPOUFETTE, MACKINAC COUNTY, MICH., *Dec. 6, 1896.*

Yours of the 21st is at hand and contents noted. Would say in regard to the planting of whitefish in the waters of Lake Michigan and the Straits of Mackinac that in my opinion it is a success so far as the young fry living is concerned. The greatest and only trouble in my opinion is in allowing the fishermen to take them out before they mature by using small mesh nets, that is in the pound or trap nets. I do not think that gill nets have much to do with the destruction of whitefish, that is the nets they use for menoninees, say 2¾ to 3-inch mesh. I have examined them closely and have not found one whitefish in a boat containing from five to eight packages.

Now in regard to pound nets. Those little fish will strike the leader and go swimming backwards and forwards through the twine until they finally bring up into the pot, where they are at a standstill, as the mesh is too small for them to get free, and they have to be taken out by the fishermen, and those that are herring size are salted and those that are too small are dumped in the offal heap.

Now I have been a pound net fisherman for 36 years and I conceived this idea 20 years ago, that if we caught off the small fish before they came to maturity, we soon ruin the lakes of the finest fish that inhabits fresh waters, and for that reason I would not use less than 4-inch mesh for my pots. I owned a good scope of ground and was not troubled with other fishermen. There was not a season but my ground paid something, some seasons more than others, until about five years ago, when they saw I was getting fish and was over one mile from shore so they had as good a right as I had to the ground, and then they planted nets on both sides of me, and for the first two years they caught about as many No. 1's as I did and put up hundreds of No. 2's and 3's in packages. The fourth year they caught nothing, neither did I.

Now, I will give you my opinion about the planting of whitefish. If they were allowed to mature, I believe they would average 75 per cent. If no fisherman could fish a smaller mesh than 4 inches, with the help of the State in five years, fish would be as plenty as they were thirty years ago.

Yours respectfully,

J. R. McLEOD.

DETOUR, MICH., *Dec. 29, 1896.*

C. H. Moore, Esq.:

DEAR SIR—You ask my honest opinion as to what I think about the planting of whitefish fry. I have always been a strong believer in it, and from my actual experience as a fisherman for over thirty years at this point, there is no question in my mind, and in fact I almost know it to be a fact, that if we had no hatchery to furnish and plant the whitefish fry, the whitefish would have been almost extinct today. As it is, about 90 per cent of all fish caught now are what we call "hatchery" fish.

I am yours respectfully,

SAMUEL BUTTERFIELD.

ST. JOSEPH, MICH., *Dec. 21, 1896.*

C. H. Moore, Detroit, Mich.:

DEAR SIR—On returning home from a leave of absence, I found your letter in regard to planting whitefish fry awaiting me and hasten to answer.

My opinion is that we are getting good results now from the planting of whitefish fry, as you will see on your next visit to St. Joseph. I caught this year more than double what I caught last year with the same number of nets, and expect to catch more next season, and I think that the increase of fish is from the planting of whitefish fry, and I am heartily in favor of continuing the same, as the fish are getting more plentiful each year as your report from this station will show.

Very respectfully,

W. L. STEVENS.

WHITEFISH POINT, L. S., MICH., *Dec. 12, 1896.*

To the Honorable Board of Fish Commissioners, Detroit, Mich.:

GENTLEMEN—It gives us great pleasure to report to you the success of the planting of whitefish in our immediately vicinity, and we do not hesitate in saying that our catch has been heavier the past few years.

The question may arise on what do we base our authority for making such a remark, and it is briefly answered. The spawn which has been gathered from the Detroit river and the lower lakes and bays create a fish different from our regular Lake Superior whitefish, both in quality and form. We must say, however, that the original Lake Superior whitefish is superior and will also bear transportation better, as they seem more firm. We sincerely regret that the season for gathering spawn on this lake is so rough that it is next to an impossibility to do so.

Hoping that you will be able to continue your good work.

We remain, respectfully yours,

C. ENDRESS & SONS.

ST. JAMES, BEAVER ISLAND, MICH., *Dec. 19, 1896.*

DEAR SIR—I found you letter on my return from Chicago and noted contents. From my observation the propagation of fish has helped to increase the whitefish, and they would be increased still further if the mesh of pound nets was 4 inches and all employed in the fishing business were forced to comply with the law. We had a good catch this fall.

Yours truly,

JAMES McCANN.

DETOUR, MICH., *Dec. 30, 1896.*

DEAR SIR—You asked me to write you what I thought of the success of the planting of what we call hatchery fish. From the expressions heard on all sides from our fishermen here, there is no doubt but what it is a success. We see it more in the whitefish than in the trout, as whitefish have been getting scarce every year for a number of years and our men claim that most all they catch now are hatchery whitefish, and it would disappoint us in more ways than one if the planting of them was stopped, which I hope it will not be.

I am yours respectfully,

JAS. T. BENNETT.

ST. JOSEPH, MICH., *May 22, 1895.*

We, the undersigned, residents of this city, for the past twenty years or more, have during all those years been actively engaged in fishing either with pound nets or gill nets out of this station in Lake Michigan and having noted the gradual decline of our yearly catches, are most decidedly of the opinion and belief that unless immediate protection is given to whitefish and lake trout, the waters of our great lakes will in the near future become practically depleted of these kinds, thereby destroying a most valuable industry. Therefore we would suggest that the State of Michigan adopt wholesome laws with this end in view, and we hereby pledge ourselves to support the same and co-operate with the State Fish Commissioners in framing a law to protect the immature whitefish and lake trout, also a close season during the spawning period of these two most valuable kinds of our lake fish.

HABIEL BROS. & CO.,
WM. HABIEL,
H. MOLLHAGEN,
ALEX. CRAU,
AMIL RISTO,
C. MOLLHAGEN & SONS,
H. O. WILSON,
COLLUM RIGNEY.

All the above signatures are St. Joe fishermen.

[From Detroit Evening News, Dec. 23, 1892.]

RAISING WHITEFISH.

E. A. DAVIS DEFENDS THE WORK OF THE FISH HATCHERIES.

TO THE EDITOR—I cannot help replying to the interview in your paper of the 22d inst., contributed by C. W. Gauthier, the wholesale fish dealer of Windsor, on fish fry. While Mr. Gauthier has been a catcher of fish all his life, I think his experience in the propagation of fish is very limited. I have experimented considerably in the raising of whitefish artificially hatched, and have obtained my fish fry from the government hatcheries. Of 2,000,000 young whitefish which I planted last April, I will venture to say 90% are alive today and thriving hale and hearty. If the gentleman can spend the time, I would be pleased to have him join me the fore part of January and I will take pleasure in showing him the little fish all alive. I will not attempt to answer his entire attack on the International Fisheries Conference, but I think he is doing them a great injustice. If it were not for the fish commission and the artificial propagation of whitefish, I think Mr. Gauthier would find whitefish a great deal scarcer than they are today in our lakes.

I have given fish culture a great deal of study in the last twelve years, as well as being a practical fisherman and I consider Mr. Gauthier away off, and can prove to him that he is.

E. A. DAVIS.

Detroit, Dec. 23, 1892.

BAY CITY, MICH., *Jan. 6, 1897.*

C. H. Moore, Detroit, Mich.:

DEAR SIR—Here are the whitefish. No charge on our part. Pardon delay. I have been more than busy and am yet.

These are smallest we have and fully twice as large as the usual run of small 3 white.

I am with you if this business can be stopped.

Yours truly,
D. A. TRUMPOUR.

ST. IGNACE, MICH., *Jan. 22, 1897.*

Mr. Herschel Whitaker, Detroit:

DEAR SIR—Your favor of the 22d inst. is received. In reply would say that we have no fish of the kind you desire on hand at present. All our fish were shipped to Chicago and stored there last fall to save freight by rail during the winter.

In the 400 half barrels we have there it is very doubtful if there is any of the kind you mention, unless they are mixed with herring. As you are aware, very few if any, are caught during the fall months. The spring and early summer is the time small whitefish are taken in large quantities.

Wish you ever success in your fight with the commercial fishermen, who care nothing for the propagation of fish when such propagation seems to conflict with their own individual gains.

I remain,
Sincerely yours,
M. CHAMBERS.

ST. IGNACE, MICH., *Feb. 16, 1897.*

Herschel Whitaker, Esq., Pres. Mich. Fish Commission, Detroit:

DEAR SIR—Yours of 9th received and in response to your queries will say, that in my opinion the principal abuses of the fisheries is in the use of small mesh in pound nets; the taking of the small fish during the months of June and July, when they come on the grounds to feed; the taking of fish in the fall on the spawning grounds (say from 20th October to 20th November); also, another, and in my opinion one of the greatest abuses, is the fishing with tugs and throwing the offal into the lake, as the decay of such offal will drive the whitefish from their feeding grounds.

My experience with the small mesh, briefly stated, is as follows: I commenced to fish pound nets in 1860 with a mesh of pot or crib of 2½ inch. That season until 1st September caught 750½ barrels, 400 of which were No. 2's and 3's. The next season, on the same grounds, I caught 400½ barrels, 100 of which were No. 1's. The third season I rented the same gounds and the parties did not get 50 pkgs. It then became apparent to me that the small mesh was destroying the fish by killing off the young fish, and from that time I kept enlarging the mesh from 2½ to 3½ inches, until 1880, when I formed a copartnership with Mr. Goodreau of Epoufette. My twine was getting poor, necessitating new pots. Without consulting Goodreau, I got 4-inch mesh for pots, and the first lift I made with them I got 17 pkgs. and Goodreau got 24 pkgs. with his old nets. He considered I had done him an injury by getting so large a mesh, as he was getting ⅓ more fish than I was, and had to divide equally. We owned together 2½ miles of shore, divided the same, I taking the west and he the east portion. He kept on fishing the 2½ and 3½ inch nets until 1890, and the last four years he did not catch fish enough to pay for the stakes. I fished my ground during the same time with the 4-inch mesh and there never was a season that it did not pay me well until 1893, when others, finding out I was fishing over a mile from shore, and consequently had as good a right to the ground as I, they set 2 and 3½ inch mesh nets alongside of me, and caught as many No. 1's as I did and put up 500½ barrels No. 2. They have continued to fish alongside of me every year since then, and the ground has failed each year. My opinion is, and in the light of experience I honestly believe, that if this ruinous practice is persisted in, in ten years time whitefish will be as scarce as oranges in Alaska.

To correct these abuses, stringent laws should be enacted, prohibiting the fishing of pound nets having less than 4 inch mesh in pots, and maintaining a close season from the 15th of October to the 20th of December in each year.

In regard to propagating fish, I am satisfied it is a good thing, as from my observation they have nearly all lived that were put in the lake by the Fish Commission. I base my opinion on the ground, that, where they have been planted there has been great numbers of small fish caught two years after, all uniform in size, and in places where there had been no fish caught in years; also they are somewhat different in make or form; they are thicker than the lake fish, according to the length.

In conclusion will say that if the health of my family and business will permit, I will be pleased to meet you at Lansing, upon notification.

JOHN R. McLEOD.

MANISTIQUE, MICH., *Dec. 8, 1896.*

Michigan Fish Commission:

GENTLEMEN—Thought I would drop you a few lines as there is some in doubt to the benefit derived in planting fish. I have been engaged in tug fishing for the past 18 years and have marked the increase on grounds that had been fished out before they commenced planting fish.

I have been in the employ of the A. Booth P. K. G. Co. for the last five years out of Manistique, and have planted each spring on grounds where there used to be fish years ago, but of late there was none until the last three years and this fall fishing was better than the two previous years and those fish I speak of are mostly whitefish and altogether like the Lake Erie fish. They are all about of a size and have no spawn in them. That is the reason I am positive they are planted fish. We also get small trout.

I have fished all the lakes and have found it the same all over from four to five years after they commenced planting fish, more so on inside grounds.

Yours truly,

CAPT. JOHN NOLAN.

ST. JAMES, MICH., *Dec. 23, 1896.*

Michigan Fish Commission, Detroit, Mich.:

GENTS—I have been called on, and I think it is a great duty to give my experience this 25 years on Lake Michigan and ten years on the ocean, but in particular of the decline of our great industry on our lakes here.

First, in 1870, when I came on these lakes, it was then new and wherever you put out nets you got whitefish and trout. They are very scarce now and I will give my reasons for the decline. Will commence at Manistique, where you could get 100 pounds to a net clear to Seul Choix. Now it is a failure. Why? The whitefish is a clean fish and feeds on feeding grounds in certain seasons of the year and on worms. They commenced dumping sawdust in the river at Manistique, which floated away in fields like fields of ice till it got water soaked and sank. Wherever this body of rank filth and dust covered the feeding ground, the fish had to go away and the young ones starved in my opinion, as their nature is like any other worm of this earth, and this would be on the same principle it would be to plow up a pasture field where there would be a flock of sheep. They go in schools on these grounds till they are banished.

The planting of whitefish commenced from our great hatchery, which has been a great benefit, more than any one is aware of, but what is the use of planting them when they are caught from the time they grow to be about two ounces to one pound in weight, so they have no chance to multiply till they are destroyed. Why are they destroyed? There has been a scheme got up to fish hooks and get bait for them, what they call bloaters, when cut bait would do as well. When you plant fish in Lake Michigan, or their natural spawn, no matter where you plant them, the young fry go together, and when they grow up they go in droves in deep water to find calm and they feed on the sides of those steep banks that are clear of filth. Then they get nets out to catch bait in those places, nets of three-quarters of an inch mesh, and get them as thick as the net can hold, of which 90% is young whitefish, and those that don't care call them bloaters, and make some fools believe that they never grow any larger. Of course this is all right to tell to a farmer in the State of Michigan, but it don't do to tell men of experience.

We here last fall got up two nets to catch bloaters for bait and we got in those puddles, 30 and 35 fathoms deep. Those nets, when we raised them, were as thick with fish so that they looked like the driven snow. Come to examine them, 90% was whitefish. The consequence was we took the nets and gave them away on the other side of the lake, as we saw we were going to destroy what we were making a living out of. It is a shame that the State would spend money today to plant fish from their hatchery and next day have them destroyed. Now they grow up to be a half pound weight and one pound, and the second year they come on the shoals and around the beach in July and August according to nature, and they get into trap nets and are caught and they don't amount to anything. It takes about 150 to 200 in count to make a hundred pounds, and they are sold for the price of barrels and salt, when if they were left one year longer, they would be all right and of some benefit to our community.

Now then the Honorable Board of Fish Commissioners should look this matter over careful to not allow any trap nets in the waters of Lake Michigan not less than 4 inch mesh when tarred and in use, and not allow any gill nets to be set in Lake Michigan outside of one mile limit from the land of any less than 4⅛ inch mesh when in fishing order. This would increase our fisheries 300% in each year.

As to short season, there is no sense to it, as we have got to get the spawn, and there is not many whitefish caught. It is all those large trout.

I have seen out of small trap nets on this shore where one-half of the catch would go in the gut barrel, as they were too small to handle.

Now, the United States, and all our states should go together and protect our lakes in regulating our meshes, as our fishing industry is a great benefit to the rich and poor. They should make districts of these chains of lakes, appoint a man by the state, pay him his salary and look out that the law would be enforced. Why not protect our fisheries as well as our game, only one is to protect the poor, the other is sport for the rich.

Hoping that our legislature this winter will see to it to get good, intelligent men on the commission that have some experience in it—Mr. Moore that takes the State statistics, I presume you know, can give you more knowledge and information than I could write for a week, because he has a great deal of experience among fishermen and knows what they want. Such men should make those laws and not men that have no experience, same as you put me raising geese on a farm, I wouldn't know anything about it.

Any further information that I can give you that may be of any benefit to you, will do so at leisure.

Kind regards,

NEIL GALLAGHER,

St. James, Mich.

FAYETTE, MICH., *Dec. 11, 1896.*

Mr. C. H. Moore, Detroit, Mich.:

DEAR SIR—Yours of the 3rd inst. just at hand, and in reply I will say that to my knowledge the planting of the whitefish fry in Summer Island Passage has been a benefit, for these reasons. During the last four or five years there has not been but a very little whitefish caught, and this season they have been scattered all over the grounds, and we have caught considerable more than we had previously, and I believe they are the same ones that were planted here a few years ago. They are decidedly different from our old ones, being much larger and a different shape.

Hoping this will meet your approval, I am sincerely

Yours,

A. BARTRAM.

CHICAGO, *Feb. 13, 1897.*

B. D. Winegar, Esq., Escanaba, Mich.:

FRIEND WINEGAR—I am in receipt of your favor of the 12th in regard to fish bill, for which I thank you. I do not know what the bill before the legislature is, but I do know that the small trout and whitefish that are caught during the fall season should be stopped. In November, December and right up to the present time even, we are getting shipments of fresh caught trout in here with an average of a third small trout that do not weigh a quarter of a pound apiece. This is outrageous and something should be done to stop it. During an open season these small trout we figure are caught during the months of November, December, January and February.

We are heartily in favor of a close season, and also regulation that will stop the fishing of the small trout and whitefish, as well as a law to punish anybody having in their possession say any amount from 15 pounds up of these small fish, no matter where they get them from.

Shall get a copy of the fish bill and take pleasure in writing you further, but would say the fishermen have written us on the subject and we have declined to take any steps in regard to it. We have spent money heretofore and accomplished nothing. Now we will sit quietly back and see if any laws are passed that will do any good. Some laws should certainly be passed, and we would rather be hurt a little, that the general business may be benefited largely, if it should be necessary.

Again thanking you,

I remain very truly yours,

W. V. BOOTH.

Mackinaw City, Mich., *Dec. 6, 1896.*

Mr. C. H. Moore, Detroit, Mich:

Your welcome letter of 5th received this a. m. It gives me pleasure to answer same as the subject you present is one of great moment to all who are in any way interested in catching or handling whitefish. The nefarious practice of some of our best pound net fishermen of setting small mesh nets on whitefish grounds with the excuse of catching herring, and then taking large quantities of small whitefish that will not weigh ¼ pound each, dressing and salting them, and selling them for herring, bringing a price hardly sufficient to pay their help for caring for the fish. I have seen 3,000 pounds of these small whitefish that you could not find a dozen fish in the lot that would weigh over ¼ pounds each taken from one ground in St. Martin's Bay. From this ground in 1894 there was taken 5,300 tbs. small whitefish, very few herring mixed with the lot, which brought the fishermen $40.28 net. This is but a sample of the fishing that is done all over the lakes. From one fishery at Point Au Sable, I have seen small whitefish mixed with herring, and have taken out of a package eight fish that weighed one pound or just two ounces each. St. Martin's Bay and Point Au Sable both in 1893 yielded good fishing, fair catches of fair-sized whitefish being taken all through the season, but the greed of the fishermen impelled them to put small mesh backs in their nets so that not a single small fish could escape to grow for their next year's fishing. No amount of talk will convince these fishermen that they are working against their own interests. They say, "If we don't catch them, our neighbors will."

Since the good catches of 1893 in St. Martin's Bay and Point Au Sable and the robbing of the waters in 1894, there has not been whitefish enough caught on these grounds to pay for setting nets, and if there is not soon some stringent legislation enacted that will prohibit the taking of these small fish that are practically worthless both to the fishermen and consumer, the elegant Mackinaw whitefish known the world over, will be a thing of the past.

Had it not been for the good work done by our Fish Commission in planting whitefish fry, I feel certain that the waters hereabouts would have been depleted ere this. But the planting of young whitefish is practically useless unless some method is adopted to protect the fish until they attain a marketable size. In my opinion the best way possible to protect these fish is to enact laws prohibiting the use of nets on whitefish grounds of a less size than 3½ inch mesh and 4 inch would be a great deal better. It would cause a great deal of trouble no doubt to the fishermen and incur quite a large expense, but there is not one of them who would not feel the benefits in a few years' time, as the whitefish would certainly increase in numbers and in size. The trouble of most of the nets now in use is this, they were made at the factory 3½ inch mesh; now, after these nets are made up and soaked in coal tar, as all pound nets are, the mesh will not measure over 3¼ inches, and the second time they are tarred it will bring them nearer 3 inches, and the whitefish that will escape from one of these nets tarred the second time must be very small.

I have talked with a number of our larger fishermen owning rigs of their own, and they all express views similar to above, that if such laws were enacted and enforced it would be a good thing for all concerned, but when one is allowed the privilege of small mesh nets, the others feel it their duty to use the same. It certainly would be a great boon to the fishermen, fish dealers and consumers if the slaughter of small whitefish could be stopped, and I feel very confident that it would not be but a very few years before we would all see good results of planting whitefish. The only reason in the world we do not see good results at present is because the young fish are caught and dumped in with herring, no one knows how many, as they are never sorted over, and are all sold for herring, that is fish under ¼ lb. weight. I am very sorry we haven't a package of those small fish to send you, as I would like to have you see them for yourself, and to show to other members of the Commission.

I am, yours truly,

W. E. ROBINSON.

APPENDIX

FISH PLANTS, 1895-1896,

TEMPERATURES AND OTHER INFORMATION.

Whitefish Plants, 1895, from Detroit House.

Name of waters.	Where deposited.	Date.	Number.
Detroit River	Pain's Dock, Belle Isle	April 2	100,000
" "	East Point, Belle Isle	" 11	7,500,000
" "	Grassy Island	" 12	3,500,000
" "	Willis' Fishery, Belle Isle	" 12	7,000,000
" "	Grassy Island	" 13	3,500,000
" "	Willis' Fishery. Belle Isle	" 13	3,500,000
" "	East Point, Belle Isle	" 14	3,500,000
" "	Grassy Island	" 15	3,500,000
" "	Willis' Fishery, Belle Isle	" 15	3,500,000
" "	Muskrat Point	" 16	3,500,000
" "	Willis' Fishery, Belle Isle	" 16	3,500,000
" "	Off upper end of Belle Island	" 16	3,500,000
" "	N. W. Side of Peche Island	" 16	3,500,000
" "	Grassy Island	" 19	3,500,000
" "	Off Peche Island	" 20	3,500,000
" "	One mile above East Point, Belle Isle	" 21	3,500,000
" "	East Point, Belle Isle	" 22	360,000
" "	East Point, Belle Isle	" 23	270,000
" "	East Point, Belle Isle	" 27	270,000
Lake Michigan	Frankfort, 8 miles northwest	" 6	2,000,000
" "	Frankfort, 8 miles west	" 10	2,000,000
" "	Ludington, 5 miles southwest	" 17	2,000,000
" "	Grand Haven	" 20	2,000,000
Lake Erie	Monroe, 3 miles northeast of mouth of Raisin River	" 9	3,000,000
" "	Monroe, near Stony Point	" 14	3,000,000
" "	Monroe, near Stony Point	" 15	3,000,000
Lake St. Clair	Grosse Point, ½ mile north of Light Ship	" 10	4,000,000
" " "	Grosse Point, 1½ mile north of Light Ship	" 14	3,500,000
" " "	Two miles north of Dummy Light	" 21	4,000,000
Straits of Mackinaw	Bois Blanc Island	" 12	2,000,000
Lake Huron	Three miles south of East Tawas	" 19	2,000,000
Total			93,500,000

Whitefish Plants, 1895, from Charlevoix House.

Name of waters.	Where deposited.	Date.	Number.
Lake Michigan	Seven miles west of Charlevoix	April 6	1,000,000
" "	Eight miles southwest of Charlevoix	" 7	2,000,000
" "	Five miles north by west off Fox Island	" 11	2,000,000
" "	Northwest of Cat Head Point	" 15	2,000,000
" "	Off Fisherman's Island	" 15	2,000,000
" "	Between Fisherman's Island and Norwood, 3 miles from shore	" 15	2,000,000
" "	Off Middle Village	" 17	1,000,000
" "	Three miles west of Norwood	" 17	2,000,000
" "	Off Cross Village	" 18	2,000,000
" "	Eight miles southwest from Charlevoix	" 19	2,000,000
" "	Mouth of Little Traverse Bay	" 20	2,000,000
" "	Five miles north of Charlevoix	" 20	2,000,000
" "	On Fisherman's Reef, 10 miles northwest of Charlevoix	" 20	2,000,000
" "	On reef 12 miles west of Charlevoix	" 20	2,000,000
" "	Manistee	" 23	2,000,000
" "	Three miles north of Charlevoix	" 25	1,000,000
Big Traverse bay	Old Mission Point	" 19	2,000,000
Pine lake	Charlevoix	" 25	1,000,000
Total			32,000,000

Whitefish Plants, 1895, from Sault Ste. Marie.

Name of waters.	Where deposited.	Date.	Number.
Hay lake	Hay Lake	April 25	1,200,000
Lake Superior	Marquette	" 29	2,000,000
" "	Mission	" 30	1,200,000
" "	Detour	May 1	2,000,000
" "	Detour	" 3	2,000,000
" "	Manistique	" 3	2,000,000
" "	Whitefish Bay	" 5	2,000,000
" "	Escanaba	" 5	2,000,000
" "	Whitefish Point	" 7	2,000,000
" "	Whitefish Point	" 9	2,000,000
" "	L'Anse	" 9	1,700,000
" "	Manistique	" 9	1,500,000
" "	St. Ignace	" 9	1,500,000
" "	Hay Lake	" 9	2,000,000
Total			25,100,000

RECAPITULATION.

From Detroit station	93,500,000
" Charlevoix station	32,000,000
" Sault Ste. Marie station	25,100,000
Total	150,600,000

Whitefish Plants, 1896, from Detroit House.

Name of waters.	Where deposited.	Date.	Number.
Detroit river	Belle Isle	April 1	1,440,000
" "	Belle Isle	" 2	360,000
" "	Belle Isle	" 2	750,000
Lake Michigan	Ludington	" 8	2,000,000
Detroit river	Grassy Island	" 9	2,510,000
" "	Belle Isle	" 10	2,510,000
Lake St. Clair	Grosse Point	" 11	2,510,000
Lake Huron	East Tawas	" 12	2,000,000
Lake St. Clair	Light Ship	" 12	3,000,000
Detroit river	Belle Isle	" 12	3,000,000
" "	Belle Isle	" 13	3,500,000
" "	Belle Isle	" 13	2,550,000
Lake St. Clair	Near Peche Island	" 14	3,500,000
Lake Michigan	Manistee	" 14	2,000,000
Detroit river	Belle Isle	" 15	3,000,000
" "	Fort Wayne	" 15	3,000,000
Lake Michigan	Frankfort	" 16	2,000,000
Lake St. Clair	Light Ship	" 16	3,000,000
" " "	Above Peche Island	" 17	3,000,000
" " "	Above Peche Island	" 17	3,000,000
" " "	Light Ship	" 18	3,000,000
Detroit river	Belle Isle	" 18	3,000,000
Lake Erie	Monroe	" 19	2,000,000
Lake Michigan	Grand Haven	" 20	2,000,000
Detroit river	Belle Isle	" 21	4,980,000
" "	Belle Isle	" 22	2,430,000
Total			66,040,000

Whitefish Plants, 1896, from Charlevoix Station.

Name of waters.	Where deposited.	Date.	Number.
Lake Michigan	Charlevoix	April 7	2,136,000
“ “	Charlevoix	“ 8	2,136,000
“ “	Charlevoix	“ 9	2,136,000
“ “	Charlevoix	“ 10	2,136,000
“ “	Charlevoix	“ 11	2,136,000
Little Traverse bay		“ 12	2,136,000
Lake Michigan	Charlevoix	“ 13	2,136,000
“ “	Middle Village	“ 14	2,136,000
“ “	Charlevoix	“ 16	2,136,000
“ “	Fox Island	“ 17	2,136,000
“ “	Fox Island	“ 21	2,136,000
Crystal lake		“ 23	1,200,000
Lake Michigan	Charlevoix	“ 24	936,000
“ “	Charlevoix	“ 25	936,000
“ “	Charlevoix	“ 26	936,000
“ “	Beaver Harbor	“ 27	936,000
Pine lake	Charlevoix	“ 28	1,021,400
Total			29,461,400

Whitefish Plants, 1896, from Sault Ste. Marie Station.

Name of waters.	Where deposited.	Date.	Number.
Sault Rapids	Sault Ste. Marie	April 18 to May 18	9,500,000
Whitefish bay	Whitefish Bay	April 24	1,000,000
Lake Michigan	Detour	“ 27	2,000,000
Hay lake	Hay Lake	“ 28	1,000,000
Straits of Mackinaw	St. Ignace	May 7	1,500,000
“ “ “	Indian Mission	“ 11	2,000,000
“ “ “	Manistique	April 27	2,000,000
“ “ “	Marquette	“ 29	2,000,000
“ “ “	Manistique	May 3	2,000,000
“ “ “	Corinne	“ 4	1,180,000
“ “ “	Escanaba	“ 18	2,000,000
Total			26,180,000

RECAPITULATION.

From Detroit station	66,040,000
“ Charlevoix station	29,461,400
“ Sault Ste. Marie station	26,180,000
Total	121,681,400

Lake Trout Plants, 1895.

County and name of waters.	Township.	Depositor.	Date.	Number.
Alcona:				
Hubbard lake	Alcona	John Ellsworth	April 2	50,000
Clear lake	Haynes	Wm. Reynolds	" 2	15,000
Antrim:				
Intermediate lake	Several	J. K. V. Agnew	May 23	20,000
Torch lake	"	" "	" 21	20,000
Central lake	Central Lake	O. P. Barker	March 20	25,000
Baraga:				
King's Head lake	Covington	N. S. Pennock	May 10	15,000
Barry:				
Pine lake	Prairieville	Ed. J. Anderson	February 25	20,000
Benzie:				
Crystal lake	Benzonia and Crystal Lake	L. T. Van Winkle	March 18	25,000
Crab lake	Almira	Fred D. Curtis	" 20	15,000
Cass:				
Diamond lake	La Grange and others	James M. Shepard	" 26	25,000
Cheboygan:				
Douglass lake	Monroe	W. E. Ford	May 2	20,000
" "	"	W. B. Stimson	" 16	40,000
Chippewa:				
Trout lake	Trout Lake	N. A. Smith & Son	April 26	10,000
Lake Huron	Off Drummond's Isl'd	John Frook	May 2	10,000
Clare:				
Town Line lake	Hayes	Geo. M. Brown	April 1	15,000
Crooked lake	Surrey	" "	" 1	25,000
Emmet:				
Carp lake	Carp Lake	J. D. Rawdon	March 28	15,000
Bear lake	Bear Creek and oth'rs	W. B Stimson	" 28	30,000
Genesee:				
Long lake	Burton	James D. Johnson	April 5	10,000
Byron lake	Fenton	Anson Shotwell	" 5	10,000
Long lake	"	C. L. Turner	March 8	25,000
Goudy lake	Forest	Hiram Jones	" 9	15,000
Gogebic:				
Thousand Islands	41 N., 41 W.	Bent Bros.	April 27	8,000
Island lake	44 N., 40 W.	" "	" 27	10,000
Grand Traverse:				
Elk lake	Several	L. L. Lydell	March 20	50,000
Silver lake	Garfield and Blair	George Simpson	May 6	20,000
Hogsback lake	Mayfield	Fred D. Curtis	April 26	10,000
Lake Brewster	"	C. E. Brewster	" 12	10,000
Houghton:				
Lake on Sec. 17	Duncan	George H. Hauser	May 9	10,000
Lake Anne	Franklin	Lawrence Corrigan	" 10	9,000
Iosco:				
Goodar lake	Thompson	J. T. Guilford	April 2	15,000
Loon lake	Plainfield	Warren S. Hodges	" 2	20,000
Isabella:				
Lestrange lake	Lincoln	Birton I. Gee	" 15	10,000
Coldwater lake	Nottawa	Robert Hyslop	" 1	25,000
Jackson:				
Pleasant lake	Henrietta	A. W. Saxton	" 19	15,000

Lake Trout Plants, 1895.—Concluded.

County and name of waters.	Township.	Depositor.	Date.	Number.
Kalamazoo:				
Gull lake	Ross and others	J. T. Upjohn	March 25	25,000
Rawson or Barton lake	Schoolcraft	John E. Pabst	April 9	10,000
Paw Paw lake	Texas and Prairie Ronde	Albert Newkirk	February 26	10,000
Wood's lake	Kalamazoo	Theo. P. Bailey	" 25	25,000
Lake:				
Star lake	Lake	Wm. H. Baldwin, Jr.	March 15	20,000
Twin lake	Webber	" " "	" 15	10,000
Lapeer:				
Skinner lake	Oregon	Hiram Jones	" 9	10,000
Dipper lake	Deerfield	Andrew Brown	April 9	10,000
Leelanau:				
Davis lake	Kasson	T. J Newman	March 18	10,000
Glen lake	Glen Arbor and others	D. H. Day	" 18	20,000
Livingston:				
Long lake	Genoa	J W Lawson	February 20	10,000
Mackinac:				
Brevoort lake	Brevoort	M. F. Mulcrume	April 26	10,000
Marquette:				
Witch lake Sawyer lake	44, 45 and 30	H. Armstrong	" 27	15,000
" "	44, 45 and 30	" "	" 27	10,000
Witch lake	44, 45 and 30	" "	" 27	15,000
Long or Iron Mountain lake	44, 45 and 30	Geo. A. Newett	May 10	10,000
Mason:				
Gunn lake	Free Soil & Sherman	Wm. H. Baldwin, Jr.	" 18	10,000
Lincoln lake	Lincoln	" " "	" 15	10,000
Round lake	Sherman	Geo. M. Brown	" 18	10,000
Mecosta:				
Clear lake	Colfax	Geo. A. Roof	February 19	10,000
Montcalm:				
Crystal lake	Crystal	De Young & Worden	March 12	20,000
Baldwin lake	Eureka	T. I. Phelps	February 20	20,000
Whitefish lake	Pierson	C, W. Hartt	" 28	25,000
Edward's lake	Home	W. R. Jones	April 29	25,000
Newaygo:				
Brill's lake	Croton	Geo King	" 23	10,000
Fremont lake	Sheridan	T. P. Hopper	May 14	15,000
Hess lake	Garfield	Edwin O. Shaw	" 14	20,000
Crystal lake	Sherman	J. Mayo	" 14	10,000
Babtist lake	Ensley	Thomas Oliver	October 5 & 7	2,050
Oakland:				
Orchard lake	W. Bloomfield	Forest S. Campbell	March 8	20,000
Lake Elizabeth	Waterford	E. W. Abbott	" 8	20,000
Long lake	Bloomfield and W. Bloomfield	T. D. Seely	April 5	25,000
Ontonagon:				
Minnesota, National and Beamer dams	50 N., 39 W.	Benjamin Jeffs	May 9	6,000
Lake Gogebic	Ontonagon	E. Vliett	" 17	50,000
Otsego:				
Calkins lake	Charlton	O. H. Carpenter	" 3	20,000
St. Joseph:				
Clear lake	Fabius	H. H. Whipple	March 4	25,000
Corey lake	"	Ad. M. Shaffer	" 5	35,000
Van Buren:				
Eagle lake	Paw Paw	F. W. Thomas	April 10	25,000
Mud lake	Antwerp	C. F. Dey	March 26	10,000
Total				1,310,050

Lake Trout Plants, 1896.

County and name of waters.	Township.	Depositor.	Date.	Number.
Antrim:				
Bower's lake	Banks	C. S. Campbell	February 27	25,000
Wilson lake	“	“ “	“ 27	25,000
St. Clair lake	“	“ “	“ 27	25,000
Banwago lake	“ & Centr'l Lake	“ “	“ 27	25,000
King's lake	“ & Echo	“ “	“ 27	25,000
Sholes lake	“ “	“ “	“ 27	25,000
Barry:				
Warren Hull lake	Baltimore	A. J. Houghtalin	“ 13	25,000
Berrien:				
Paw Paw lake	Watervliet and Coleman	Geo. F. Collett	“ 5	10,000
Cass:				
Mud lake	Calvin	I. R. Wright	“ 6	10,000
Christian lake Juno lake	Ontwa	Manning Rogers	March 3	20,000
Painter lake	Calvin & Jefferson			
Charlevoix:				
Lake Michigan	Off Charlevoix	Mich. Fish Com	April 1	250,000
“ “	“ “	“ “ “	“ 3	250,000
“ “	“ “	“ “ “	“ 7	250,000
Chippewa:				
Detour passage	Detour	“ “ “	May 4	150,000
Espanore lake	Drummond	Chase S Osborne	“ 4	25,000
Lake Superior	Whitefish Point	Mich. Fish Com	“ 4	150,000
Whitefish bay	“ “	“ “ “	“ 4	122,000
Sault river	Sault Ste. Marie	“ “ “	“ 4	2,000
Clare:				
West lake	Grant	O. S. Derby	March 17	20,000
Middle lake	Hatton	“ “	“ 17	20,000
Clinton:				
Round lake	Victor	J. C. Shaver	February 21	25,000
Crawford:				
K. P. lake	Maple Forest	George T. Owen	March 10	25,000
Shoepack lake	28 N., 1 W.	Ed. O'Brien	“ 10	25,000
Emmet:				
Crooked lake	Little Traverse	Thos. F. Austin	“ 5	25,000
Genesee:				
Long lake	Fenton	J. W. McCullom	February 21	25,000
Gogebic:				
Lake Gogebic	Ontonagon & Gogebic	L. L. Wright	May 15	25,000
Grand Traverse:				
Silver lake	Garfield	Frank Frederick	March 13	25,000
“ “	“	George Simpson	February 27	25,000
Houghton:				
Misery lake	Adams	Lawrence Corrigan	May 12	25,000
Isabella:				
Coldwater lake	Nottaway	Robert Hyslop	March 10	25,000
Kalamazoo:				
Asylum lake	Kalamazoo	Herman Ostrander	February 10	10,000
Hogsett lake	“	P. C. Pursel	March 3	10,000
Gull lake	Kearney and Kalamazoo	C. E. Foote	April 15	25,000
White's lake	Kalamazoo	“ “	“ 15	10,000

Lake Trout Plants, 1896.—CONCLUDED.

County and name of waters.	Township.	Depositor.	Date.	Number.
Lapeer:				
Miller lake	Deerfield	Will J. Till	February 18	25,000
Palmerlee lake	Lapeer	Chauncy Tibbetts	" 18	10,000
Otter lake Powderhorn lake Parke lake	Marathon	J. C. Mason	" 18	50,000
North lake	"	I. M. Fisher	" 18	25,000
Leelanau:				
Glen lake	Glen Arbor and others	D. H. Day	" 18	25,000
Lenawee:				
Sand lake	Franklin and Cambridge	J. J. Putnam & Sons	March 3	25,000
Devil's lake	Rollin and Woodstock	Geo. R. Beardsell	" 3	25,000
Mason:				
Round lake	Sheridan	C. O. Holmes	" 20	25,000
Montcalm:				
Hemingway lake	Day	E. S. Stebbins	February 15	25,000
Whitefish lake	Pierson	C. W. Hartt	March 25	25,000
Muskegon:				
Big Blue lake	Blue Lake	E. D. Magoon	February 22	25,000
Newaygo:				
Bill lake	Croton	George King	March 17	25,000
Oakland:				
Mace Day lake Lotus lake	Waterford	A. W. Blain	February 21	25,000
Ontonagon:				
Lake Gogebic	Ontonagon	J. M. Whitman	May 15	75,000
Otsego:				
Big lake	Chester	A. A. Crane	March 6	25,000
St. Joseph:				
Pleasant lake	Fabius	H. H. Whipple	February 6	25,000
Corey lake	"	J. H. Hahn	" 6	25,000
Crosman lake	Sherman	John McKerlie	March 26	15,000
Klinger's lake	White Pigeon	" "	" 26	35,000
Total				2,294,000

Brook Trout Plants, 1895.

County and name of waters.	Township.	Depositor.	Date.	Number.
Alcona:				
Black river	Haines	James E. Henderson	April 2	2,000
Mill creek	Harrisville	L. A. Colwell	“ 2	5,000
Stony creek	Haines	Addison Silverthorn	“ 2	5,000
Backus creek	26 N., 8 E.	A. Backus, Jr.	“ 2	4,000
Elm stream Indian river	Harrisville	H. W. Lyman	“ 2	2,500
West Branch	26 N., 8 E.	A. Backus, Jr.	“ 2	2,000
Dural creek	Mikado	C. W. Luce	“ 2	8,000
Allegan:				
George's creek	Trowbridge	Edwy C. Reid	February 25	2,500
Doud's creek	Heath	“ “	“ 25	5,000
Clifford creek	Trowbridge	“ “	“ 25	2,500
Sink brook	Heath	“ “	“ 25	2,500
Bear creek	Monterey and Heath	“ “	“ 25	5,000
Mill creek	Monterey	“ “	“ 25	2,500
Sand creek	Pine Plains	“ “	“ 25	2,500
Spectacle brook	Monterey	“ “	“ 25	2,500
Indian stream	Wayland	John A. Turner	March 25	1,000
Cold Stream creek	Otsego	Buchanan R. Jones	“ 25	2,000
Silver creek	Gun Plains	C. D. Stewart	“ 25	2,500
Adsit creek	Watson	Fred Tubbs	“ 25	2,000
Franklin creek	Alamo and Otsego	“ “	“ 25	3,000
White's creek	Gun Plains	Conrad Bros.	“ 25	2,000
Adsit creek	Watson	H. D. Mills	“ 25	5,000
Butter creek	Otsego & Gun Plains.	John N. Perkins	“ 25	2,000
Spring Grove creek	Otsego	John D. Woobeck	“ 25	2,000
Town Line creek	Pine Plains	Lafayette Stuch	February 25	5,000
Alpena:				
Crowell creek Morse creek	Ossineke	W. E. Wright	April 2	8,000
Gurkey creek	Sanborn	W. F. Haskin	“ 2	5,000
Antrim:				
Wilson creek	Banks	Jeff. Bearrs	March 20	1,000
Dryer creek	“	“ “	“ 20	1,000
Dick creek Wood creek	“	“ “	“ 20	3,000
Boss creek	“	“ “	“ 20	2,500
Crampton creek Wittse creek Burdeck creek Mohnmeau creek	Central Lake	C. E. Ramsey	“ 20	8,000
Cedar river and branches	Kearney and Custer	O. W. Kibby	“ 20	12,000
Cold creek	“ “ “	“ “	“ 20	2,500
Cedar river Cold creek	Kearney	Arthur Watkins	“ 20	5,000
Spencer creek	Helena	Main & Sanford	“ 20	5,000
Arenac county:				
Branch of the Au Gres river	Turner	George Lewis	April 2	5,000
Barry:				
Britten creek	Barry	Calvin Stanton	February 14	2,000
Polly creek	“	“ “	“ 14	1,000
Stanley creek	Hastings	Luke Waters	“ 14	2,000
West or Kenny creek	Rutland	Sidney A. Crowell	“ 14	2,000
Kada creek	“	“ “	“ 14	2,000
Cherry creek	Hastings	“ “	“ 14	2,000
Butler's creek	“	“ “	“ 14	2,000
Lane's creek	Rutland	“ “	“ 14	2,000
Bentley's creek	“	“ “	“ 14	2,000
Fuller brook	Carlton	Kip Silsbee	“ 14	1,000
Mangham creek	Baltimore	W. H. Spence	“ 14	2,000
Kelley or Spence brook	“	“ “	“ 14	6,000
Big Spring brook	Barry	Jett Letts	“ 14	1,000
Hill creek	Hastings	Jacob H. Neiss	“ 14	2,500
Mitchell creek	Irving	“ “	“ 14	2,000
Leonard's creek	“	Luther S. Hills	“ 14	1,000

Brook Trout Plants, 1895.—CONTINUED.

County and name of waters.	Township.	Depositor.	Date.	Number.
Barry—*Continued:*				
Fall creek	Hastings	W. D. Hayes	February 14	3,000
Ingram creek	Irving	John Kurtz	" 14	2,000
Horn creek	Johnstown	Charles Pritchard	" 14	1,000
Fisher's creek	Baltimore	" "	" 14	1,000
Prichard brook	"	" "	" 14	2,000
Tamarack creek	Hastings	Peter Cockburn	" 14	1,500
Stream on Secs. 33 and 28	Rutland	Thos. E. Waters	" 14	2,000
Stream on Sec. 15	Hastings	A. J. Sponable	" 14	2,000
Pratt creek	"	" "	" 14	2,500
Not named	Rutland	J. M. McElwain	" 14	1,500
Orr creek	Irving	" "	" 14	2,500
Mill creek	Carlton	" "	" 14	1,500
Haney creek	Rutland	" "	" 14	2,000
Stream on Sec. 24	"	F. H. Barlow	" 14	2,000
Stream on Sec. 33	"	" "	" 14	2,000
Erb creek	Hastings	Edmund Schuneman.	" 14	2,000
Stream on Sec. 6	Johnstown	Francis Stanton	" 14	1,000
Linnington creek	Rutland	J. H. Linnington	" 14	1,000
Stream on Sec. 34	Carlton	R. K. Grant	" 14	1,000
High Bank creek	Baltimore	Isaac Powell	" 14	5,000
Glass creek	Rutland	E. G. Holbrook	" 14	2,500
Silver creek	Yankee Springs	Luther S. Hills	" 14	1,000
Glass creek	Irving	" "	" 14	3,000
Stream on Sec 31	Burlington	Edgar Fisher	" 14	1,500
Quaker brook	Maple Grove	Taylor Walker	" 14	5,000
Ellis brook	Assyria	P. K. Jewell	" 14	2,500
Salisbury creek	Orangeville	Eli Nichols	" 14	5,000
Griffin creek	Rutland	P. T. Colgrove	" 14	3,000
Kenfield creek	Hastings	" "	" 14	3,000
Heney, branch of West creek	Rutland	" "	" 14	3,000
Baraga:				
Slate river	Avon	N. S. Pennock	May 24	5,000
Pine creek	Baraga	" "	" 24	5,000
Carp river	"	" "	" 24	5,000
Benzie:				
Herring creek	Blaine	A. O. Wheeler	April 17	5,000
Cold Spring creek Eden Branch Cedar creek	Benzonia	L. T. Van Winkle	March 18	5,000
Little Betsey river	Weldon	C. Stein	" 18	4,000
Crystal creek	Benzonia	" "	" 18	2,000
Big Betsey river Little Betsey river	Colfax	A. C. Wilkinson	" 20	7,500
" " "	"	W. Cherryman	" 20	7,500
Clay Creek	Inland & Homestead.	J. K. V. Agnew	" 20	8,000
Berrien:				
Tributary to Hickory creek	Lincoln & Royalton	J. H. Hatch	February 26	2,000
Zearing's creek	Galien	D. F. Bommerscheim	" 26	2,000
Spring creek	Three Oaks	" "	" 26	2,000
Warren's creek	Chickaming	" "	" 26	2,000
Jeffries creek	Galien	Lyanges Jeffries	" 26	2,000
Kinnies creek	Three Oaks	D. F. Bommerscheim	" 26	2,000
Estes brook Day brook	Buchanan	L. L. Redden	" 26	1,000
Brandywine creek	Niles	Lewis H. Beeson	" 26	2,500
" "	"	Geo. W. Dougan	" 26	2,500
Lemon creek	Oronoko	Geo. Whitman	" 26	5,000
Branch:				
Riley's creek	Sherwood	W. H. Hubbard	May 5	3,000
Walter's Spring brook	California	M. G. Clarke	February 28	1,000
Porter's Spring brook	"	Ed. J. Allen	" 28	1,000
Stream on Sec. 2	Kinderhook	Albert A. Dorrance	" 28	1,000
Shinneman's creek	Batavia	Henry H. Barlow	" 28	2,000
Crooked creek	Kinderhook	C. D. Warner	" 28	3,000
Noble creek	Noble	" "	" 28	3,000
Stream on Secs. 1 and 2	Kinderhook	" "	" 28	1,000
Vincents' brook	Girard	L. M. Wing	" 28	1,000
Calhoun:				
Pine creek	Athens & LeRoy	W. H. Hubbard	March 5	2,500
Alder creek	Burlington & Newton	Zachariah Little	" 5	2,500
Harsh creek	Burlington	Cyrenius B. Knight	" 5	2,500
Sanders' creek	"	Edson Treadwell	" 5	2,000

Brook Trout Plants, 1895.—CONTINUED.

County and name of waters.	Township.	Depositor.	Date.	Number.
Calhoun—*Continued:*				
Wormley's creek	Marshall	J. F. Garwood	March 4	2,500
Enos brook	"	" "	" 4	2,500
Knight's creek	"	" "	" 4	2,000
Tamarack creek	"	" "	" 4	1,000
Loomis creek	Eckford	" "	" 4	4,000
Pigeon creek	Marshall	" "	" 4	2,000
Pigeon creek	Eckford	" "	" 4	2,500
Cass:				
Jones creek	La Grange	C. H. Kimmerlee	" 26	3,000
Sharpe's creek	Jefferson	" "	" 26	2,000
Stephenson creek	"	" "	" 26	2,000
Pokagon creek	Pokagon & Howard	" "	" 26	2,000
Centennial Mills creek	La Grange & Jeffers'n	" "	" 26	2,000
Shaw's creek	Jefferson & Howard	" "	" 26	2,000
Smith's creek	" "	" "	" 26	4,000
Conklin creek	Marcellus	E. P. McKenzie	" 26	2,500
Spring brook	Newbury	C. S. Jones	" 26	1,000
Big creek	Marcellus	W. L. Arnold	" 26	5,000
No name	"	" "	" 26	2,000
Mechanicsburg creek	La Grange	A B. Atwater	" 26	3,000
Stream on Secs. 24 and 25	Jefferson	Edward Keegan	" 26	3,000
Smith's creek	"	S. S. Congdon	" 26	1,000
Hadsell's creek	Jefferson & Howard	John Congdon	" 26	2,000
Stream on Secs. 27, 28 and 33	La Grange	A. M. Kingsbury	" 26	2,500
Schutte's creek	Jefferson	S. C. Thorpe	" 26	2,500
Spring Lake creek	"	" "	" 26	2,000
Pea Vine creek	Pokagon	F. L. Colby	February 26	2,500
Brandywine creek	Howard	Lewis H. Beeson	" 26	2,500
Charlevoix:				
Ironwood creek	Norwood	L. D. Bartholemew	March 20	2,500
McGeogh creek	Marion	" "	" 20	2,500
Stover's creek	Charlevoix	" "	" 20	2,500
Spring brook, br. of Bear river	Melrose	W. B. Stimson	" 28	5,000
Cheboygan:				
Spring creek	Burt	Wm. Hawkins	" 22	2,000
Middle branch of Little Sturgeon river	T. 34 and 35 N., R. 2 W.	Henry J. Graves	" 22	3,000
Cold Creek	T. 35 N., R. 2 W.	" "	" 22	1,000
Mett creek	Hebron	John Reycraft, M. D.	" 22	2,000
Stewart creek	T. 33 N., R. 2 W.	R. H. L'Hommedieu.	" 22	12,000
Chippewa:				
Sault Ste. Marie river		Mich. Fish Com.	May 9	148,000
" " " "		" " "	" 18	15,000
Bear creek	Rudyard	John H. D. Everett	" 15	12,000
Clare:				
No name	Surrey	Nat. D. Watkins	April 1	3,000
Headwaters of the Chippewa river and its branches	"	John VanValkenburg	" 1	10,000
Several lakes and streams on Secs. 8, 9, 16, 20 and 33	T. 17 N., R. 4 W.	Geo. M. Brown	" 1	3,000
Silver creek	T. 17 N., R. 4 W.	" "	" 1	4,000
South branch of Tobacco river	Several townships	H. C. Potter	" 1	6,000
Middle " " " "	" "	W. B. Mershon	" 1	7,500
Newton creek	Surrey	E H. Smith	" 1	3,000
Chippewa river	Several	C. H. Davis	" 1	6,000
Dock and Lowe creek	Surrey	Harry T. Wickes	" 1	10,000
North branch of Tobacco river	Several	Wm. F. Potter	" 1	10,000
Clinton:				
Meadow brook	Eagle	Frank S. Byam	March 21	2,500
Coon creek	Middleburg and Siota	J. A. Valentine	" 12	5,000
Post creek	Victor	Elisha F. Edwards	" 12	3,000
Little Maple river	Ovid	F. D. Cleveland	" 12	4,000
Crawford:				
East branch of Au Sable river.	T. 27 N., R. 3 W.	R. H. L'Hommedieu.	" 22	15,000
Br. of S. br. " " "	Center Plains	" "	" 22	15,000
North bra'ch " " "	T. 28 N., R. 1 W.	" "	" 22	18,000
Delta:				
Day's river	Mas'nville & Baldwin	Richard H. Mertz	April 27	9,000

Brook Trout Plants, 1895.—Continued.

County and name of waters.	Township.	Depositor.	Date.	Number.
Eaton:				
Sand brook	Vermontville	Benjamin Haight	February 14	3,000
Jordan brook	Chester	F. S. Jordan	“ 14	2,000
Mill creek	Walton and Lee	Samuel Curtis	“ 28	8,000
Town Line brook	Walton and Carmel	E. R. Moran	“ 28	4,000
Emmet:				
Minnehaha creek	Littlefield	W. B. Stimson	March 28	5,000
Maple river	Pellston	“ “	“ 28	12,000
Town Line creek	Oden	“ “	“ 28	4,000
Syder creek	“	“ “	“ 28	4,000
Conway Spring brook	“	“ “	“ 28	4,000
Bear river	Clarion	“ “	“ 28	10,000
Bird's Eye creek	Littlefield	“ “	“ 28	6,000
Gladwin:				
Sugar river	Butman & Sherman	Geo. M. Brown	April 1	10,000
Cedar creek	Beaverton and others	F. L. Prindle	March 22	6,000
McNellie creek	Sage	“ “	“ 22	3,000
Gogebic:				
Maple creek	Ironwood	Chas. M. Winter	April 27	3,000
Duck creek	Watersmeet	A. D. Johnston	“ 27	3,000
“ “	“	L. L. Wright	“ 27	3,000
Ontonagon river	“	“ “	“ 27	3,000
Little Presque Isle river	“	“ “	“ 27	5,000
Powder Mill creek	Bessemer	Thos. Kissane	“ 27	3,000
Welch creek	Ironwood	L. C. Walker	“ 27	3,000
East br. of Presque Isle river	Marenisco	L. L. Wright	“ 27	3,000
Black river	Bessemer	“ “	“ 27	3,000
Steam on Secs. 9, 16, 17	T. 46 N., 43 W.	“ “	“ 27	1,500
Not named	Ironwood	“ “	“ 27	4,000
Montreal river	“	“ “	“ 27	4,000
Hammond's creek	“	“ “	“ 27	3,000
Ontonagon river	Watersmeet	A. D. Johnston	“ 27	3,000
Grand Traverse:				
Boardman river	Whitewater	L. L. Lydell	March 20	20,000
Mill creek	“	“ “	“ 20	2,000
Keiser's creek	“			
Barker creek	“	“ “	“ 20	4,500
Mill creek	“			
Whitewater creek	“			
Tributary to Platte river	Long Lake	Jeremiah M. Thomas	“ 20	5,000
Crane's creek	Blair & Green Lake	D E. Crandall	“ 20	1,000
Hillsdale:				
Bear creek	Cambria	Ed. D. Babcock	February 28	2,000
Harrison's creek	“	M. G. Mallery	“ 28	1,000
Headwaters of St. Joseph river	Jefferson	Marion G. Mosher	“ 28	2,500
Fellow's creek	Pittsford	James B. Thorn	“ 28	3,000
Britton's creek	“	“ “	“ 28	8,000
Bean creek	“			
Hillsdale creek	“			
Houghton:				
Salmon Trout creek	Adams and Hancock	N. E. McBride	May 24	3,600
Stoll's creek	Hancock	A. R. Gray	“ 24	3,600
Cole's creek	Adams and Hancock	J. A Hubbell	“ 24	3,600
Swede Town creek	“ “ “	James B. Sturgis	“ 24	3,600
Graveract creek	Hancock	J. F. Bowden	“ 24	3,600
Sidnaw creek	47 N., 35 W.	Geo. H. Houser	“ 24	5,000
Breauno river	Laird	Leonard Gillespie	“ 24	4,000
Huron:				
Willow Spring brook	Verona	J. B. Madill	April 10	6,000
Ingham:				
Seely's creek	Delta and Lansing	Dewey A. Seely	February 20	3,000
Ionia:				
Prison creek and ponds	Ionia	Otis Fuller	April 7	500
Cryderman creek	Darby	W. D. Crane	February 20	1,000
Stocking's creek	Otisco	H. J. Leonard	“ 20	2,500
Common's Mill pond				
Popple creek	Ronald	H. E. Howarth	March 12	4,000

Brook Trout Plants, 1895.—CONTINUED.

County and name of waters.	Township.	Depositor.	Date.	Number.
Iosco:				
Coal creek Spring brook	Au Sable Wilber	C. R. Henry	April 2	6,000
Indian creek	Oscoda	John Tadgahsong	" 2	8,000
Sims creek	Tawas and Baldwin	C. W. Luce	" 2	5,000
Cold creek	" " "	" "	" 2	6,000
Gailey creek	Plainfield	" "	" 2	8,000
Smith creek	Plainfield, Grant and Sherwood	" "	" 2	8,000
East branch of Au Gres river	Plainfield, Grant and Sherwood	" "	" 2	16,000
Isabella:				
Pumphrey creek	Rolland	J. K. V. Agnew	March 12	4,000
Skunk creek	"	" "	" 12	18,000
" "	"	W. R. Jones	" 12	12,000
Child's creek Cedar creek	Coe Lincoln	L. D. Estee	" 13	8,000
No. branch of Chippewa river	Gilmore	C. H. Freeman	" 1	2,500
Onion creek	Chippewa	Geo. L. Granger	" 1	6,000
Mission creek	Union	" "	" 1	6,000
Healey creek	Deerfield	" "	" 1	3,000
Johnson creek	Union	Warner Churchill	" 1	2,500
Notaway creek North branch of Cedar creek	Notawa	Geo. L. Granger	" 1	5,000
Jackson:				
Muckey creek	Rives	Grove H. Wolcott	February 14	2,500
Kipps brook	Summit	George Meister	" 14	2,000
Mills creek	"	" "	" 14	3,000
Crouch creek	"	" "	" 14	3,000
Not named	Summit & Liberty	J. G. O'Dwyer	" 14	2,000
Locher stream	Grass Lake & Waterloo	D. W. Clark	" 14	3,000
Spring brook	Spring Arbor & Concord	F. C. Courter	March 4	5,000
R. R. pond	Rives	Will D. Casey	" 5	1,000
Cleland stream	Hanover	W. W. Dew	" 5	2,500
Williams' creek	"	A. S. Ambrose, M. D.	" 5	2,000
Thompson's Spring brook	"	Eugene Strait	" 5	3,000
Townsend Spring brook	"	" "	" 5	2,500
Trib. to Grand river, on Sec. 23	Liberty	Chas. Van Schoick	" 5	6,500
Wheaton spring	Hanover	E. S. Heath	" 5	1,500
Gillets creek	Springport	F. C. Courter	" 4	3,000
Spring creek	Parma	" "	" 4	5,000
Kalamazoo:				
Klein brook	Flowerfield	Chas. W. D. Allen	February 28	5,000
Chamberlain creek	Prairie Ronde	John E. Pabst	" 20	5,000
Bly creek	" "	Henry I. Allen	" 28	5,000
Cogles creek	" "	W. C. Kohl	" 28	1,000
Taylor's creek	Schoolcraft	John Harrison, Jr.	" 28	2,000
Frakes creek	"	J. W. McElwain	" 28	2,500
Little Portage creek	Wakeshma	C. Z. Hasbrouck	" 28	5,000
Pierce and Bellows creeks	Charleston & Climax	H. Dale Adams	March 4	4,000
Ridler and Earl creeks	Charleston & Comstock	" "	" 4	3,000
Hinton creek	Ross	" "	" 4	3,000
Eagle or Streator creek	Charleston & Ross	Harry D. Streator	" 4	4,000
Dixon's creek	Alamo	Fred Tubbs	February 25	3,000
Pine creek	"	G. E. Barden	" 25	9,000
Little Portage creek	Texas & Kalamazoo	A. J. Stevens	" 25	2,500
Silver creek Seely's creek Brown creek Duncan creek	Alamo	Ed J. Anderson	" 25	5,000
Not given		A. L. Lakey	May 21	3,000
Kalkaska:				
Rapid river	Rapid River	W. B. Stimson	" 28	12,000
South br. of Boardman river	Boardman	" "	" 28	15,000
Middle br. of Boardman river	"	" "	" 28	5,000
North br. of Boardman river	Kalkaska	" "	" 28	10,000
Rapid river	Rapid River	" "	" 28	7,000
Kent:				
Whitney creek	Plainfield	D. L. Stevens	April 8	3,000
Stegman creek	Courtland & Algoma	F. E. Wright	February 27	2,500
Shaw creek	" " "	" "	" 27	2,000

Brook Trout Plants, 1895.—CONTINUED.

County and name of waters.	Township.	Depositor.	Date.	Number.
Kent.—*Continued:*				
Rum creek	Courtland & Algoma	F. E. Wright	February 27	2,000
Barkely creek	Cannon & Plainfield	" "	" 27	2,500
Tanner creek	Algoma	Robert Carlyle	" 27	1,500
Barclay creek Leache creek	Cannon & Plainfield	" "	" 27	2,500
Hutchins creek	Algoma & Plainfield	" "	" 27	1,500
Austin creek	Courtland	" "	" 27	2,000
Baker creek	Cannon	" "	" 27	2,000
Little Cedar creek	Courtland & Algoma	W. H. Wheeler	" 27	7,500
Silver creek	Tyrone & Sparta	C. C. Darling	March 14	2,000
Ball creek	" " "	" "	" 14	2,000
Sparta creek	Sparta	" "	" 14	2,500
No name	No. part of Tyrone	J. S. Ingram	" 14	1,000
Tributary to Bear creek	Byron	Frank Narregaug	February 26	2,000
Butternut creek	Byron & Gaines	" "	" 26	2,000
Tributary to Rush creek	Byron	" "	" 26	1,000
Beaver Dam creek	"	" "	" 26	2,000
Smith's creek	Caledonia	D. W. Dutcher	" 14	2,000
Stream on Sec. 24	"	" "	" 14	2,000
Becker creek	Courtland	Henry Parkinson	" 25	2,000
Rogue river	Plainfield	W. B. Stimson	March 25	10,000
Shaw's creek	Algoma	" "	" 25	5,000
Edgerton creek	"	" "	" 25	10,000
Lake:				
Br. of Little Manistee river	Ellsworth	H H Morley	" 14	2,500
Little Sweetwater creek	Elk	J. S. Stearns	" 15	6,000
Buck creek	Lake & Branch	C. H. Bates	" 18	2,000
Little Manistee river	Center	" "	" 18	2,000
West br. of Dannaher creek	Pleasant Plains	J. F. Brand	" 18	2,000
Bowman creek	Lake	C. H. Bates	" 18	2,000
North Branch	19 and 20 N., 12 W.	A. Patriarche	" 18	5,000
Little Manistee river	19 N., 13 W.	" "	" 18	4,000
Avery creek	Cherry Valley	W. A. Avery	" 18	3,000
Daniher creek	Pleasant Plains	L. A. Carpenter	" 18	1,500
Sanborn creek	Three Towns	B. B. Mitchell	" 18	5,000
Middle branch of Pere Marquette	" "	R. H. L'Hommedieu	" 18	4,000
Lacey creek	Yates	" "	" 18	3,000
Irons creek	Elm & Elk	J. K. V. Agnew	" 20	12,000
Little Danaher creek	Plains	" "	" 20	5,000
Little Manistee river	Ellsworth	W. B. Stimson	" 28	10,000
Lapeer:				
Dutch creek	Oregon	Hiram Jones	" 9	3,000
Webster creek	Hadley	M. F. Hemmingway	" 9	5,000
Brocker creek	"	" "	" 9	2,500
Hemmingway creek	"	" "	" 9	2,500
Branch of Hunters' creek	Lapeer	C. A. Smith	" 9	2,500
Farmers' creek	Metamora & Hadley	R. B. Conklin	" 9	8,000
Branch of Farmers' creek	" " "	Jesse Lee	" 9	3,000
Leelanau:				
Streams and pond on Secs. 3, 4 and 32	Leelanau	N. E. DeGolier	" 20	5,000
Lenawee:				
Woodward creek	Franklin	H. H. Halladay	" 5	2,500
Evans creek	Franklin & Tecumseh	M. J. Pierce	" 5	6,000
Livingston:				
Cedar creek	Marion	Daniel O. Smith	February 20	7,500
Macomb:				
Troop creek	Bruce	H. W. Bradley	March 8	2,000
Eldred's creek	"	" "	" 8	2,000
Streetor's creek	"	" "	" 8	2,000
Smith creek	Washington	" "	" 8	2,000
Stream on Secs. 4 and 33	Bruce	" "	" 8	2,000
Frost's creek	Washington	" "	" 8	2,000
Mackinac:				
Coldman creek	Garfield	Wm. Hudson	April 26	3,000
Carp river	St. Ignace	W. M. Spice	" 26	9,000
Cool creek	Garfield	Wm. Hudson	" 26	3,000

Brook Trout Plants, 1895.—CONTINUED.

County and name of waters.	Township.	Depositor.	Date.	Number.
Manistee:				
Kill or Kinnie creek	Brownstown	C. Stein	March 18	2,000
Conger creek	Maple Grove	J. K. V. Agnew	“ 20	10,000
Corfu creek	Brown	“ “	“ 20	4,000
Bear creek branch	Cleon	W. R. Smith	“ 18	3,000
Gable creek	“	“ “	“ 18	3,000
Seder creek	Maple Grove	Alfred H. Mills	“ 18	6,000
Marquette:				
Little Falls creek	Republic	Peter Pascoe	May 24	6,000
North branch of west branch of Escanaba river	Tilden and Palmer	Geo. A. Newitt	“ 24	6,000
Mason:				
Lincoln creek	19 N., 15 W.	Geo. M. Brown	March 18	5,000
Big Sable	20 N., 15 W.	Wm. H. Baldwin, Jr.	“ 18	15,000
Weldon creek	Branch	Farnham Lyon	“ 18	3,000
Dan Whalen’s creek	Amber	Valentine R. Penny	“ 18	3,000
Geobolt’s creek	“	“ “	“ 18	3,000
Upper Weldon creek	Branch	Henry C. Rawson	“ 15	3,000
Mecosta:				
Black creek	Millbrook	J. K. V. Agnew	“ 12	5,000
Little Chippewa river	Sheridan	“ “	“ 12	8,000
Bambee creek	“	“ “	“ 12	5,000
Randy branch	Martiny & Chippewa	“ “	“ 12	12,000
Marshfield creek	Colfax	J. W. Meller	“ 12	8,000
Pointer creek	Wheatland & Norton	J. K. V. Agnew	“ 12	4,000
Hughes creek	Martiny	“ “	“ 12	7,000
Stream on Secs. 17 and 20	Chippewa	James A. Roof	“ 12	1,500
Roundy creek	“	“ “	“ 12	2,500
Black Lake creek	Millbrook & Belvidere	Lorenzo D. Decker	“ 12	2,000
Black creek	“ “	H. Cogswell	“ 12	4,000
Mack’s creek		W. B. Stimson	February 19	7,000
West branch of Pine river	Millbrook & Rolland.	N. C. Mason	March 12	5,000
Little Muskegon	Deerfield	W. B. Stimson	“ 25	10,000
Borland creek	Ætna	“ “	“ 25	10,000
Midland:				
Warner’s creek	Geneva	L. F. Babcock	April 1	2,500
Bluff creek	Jerome and Warren.	“ “	“ 1	8,000
Babcock creek	Geneva	“ “	“ 1	1,000
Missaukee:				
Wallis creek	Lake	G. W. Crosby	March 28	4,000
Clam creek	Lucas	D. B. Kelley	“ 13	15,000
Montcalm:				
Town Line Lake creek	Belvidere	J. K. V. Agnew	“ 12	6,000
Brandy creek	Winfield & Hinton	Frank J. Rosseau	“ 12	2,500
Bushley creek	Cato & Winfield	S. J. Youngman	“ 12	6,000
Riches creek	Cato & Belvidere	“ “	“ 12	6,000
West branch of Flat river	Pine	“ “	“ 12	2,000
Horse Shoe Lake creek	Belvidere	“ “	“ 12	2,500
Stream on Secs. 21, 23 and 27	Pine	“ “	“ 12	2,500
Irving creek	“	“ “	“ 12	5,000
Wiley creek	Cato, Pine & Douglas	“ “	“ 12	8,000
West branch of Flat river	Pine & Montcalm	“ “	“ 12	8,000
Lahar creek	Home	W. R. Jones	“ 12	8,000
Giger creek	“	“ “	“ 12	7,000
Sacketts creek	“	“ “	“ 12	2,000
Kirby creek	“	“ “	“ 12	2,000
Two east br. of Cedar creek	Day	James McCrea	“ 12	8,000
Tamarack creek	Winfield and Cato	J. K. V. Agnew	“ 12	15,000
Castle creek	Bushnell	H. E. Howarth	“ 12	4,000
Stoney creek	Sidney	F. H. French	“ 12	2,500
Dickerson creek	“	C. Ellis Elliott	“ 12	6,000
West branch of Fish creek	“ and Douglas.	“ “	“ 12	2,000
Sucker creek	Pine and Douglas	“ “	“ 12	4,000
Spring creek	Pine	“ “	“ 12	4,000
Lucas creek	Douglas	“ “	“ 12	4,000
Reed creek	Day	G. T. Howarth	“ 12	2,000
Willet creek	Evergreen	“ “	“ 12	4,000
Branch of Fish creek	Sidney	S. Benj. Young	“ 12	2,000
Horse Shoe creek	Montcalm	T. I. Phelps	February 20	2,500
Spring creek	Maple Valley	Sid V. Bullock	“ 20	2,000
Cedar creek	Winfield	“ “	“ 19	3,000
Church creek	“	S. C. Scott	“ 19	4,000

Brook Trout Plants, 1895.—CONTINUED.

County and name of waters.	Township.	Depositor.	Date.	Number.
Montcalm—*Continued:*				
Handy creek	Reynolds, Winfield and Cato	S. C. Scott	February 19	8,000
Rice creek	Pierson and Reynolds	" "	" 19	2,000
Salt Springs creek	Eureka	T. I. Phelps	" 20	2,500
Clifford creek	Montcalm	" "	" 20	2,500
Spring creek	Eureka	" "	" 20	2,500
Wilcox creek	"	" "	" 20	2,500
Spring brook	Day and Ferris	S. Frost	March 12	3,000
Tamarack river	Reynolds	W. B. Stimson	" 25	10,000
Muskegon:				
Silver creek	Whitehall	E. M. Ruggles	" 14	4,000
Thomas creek				
Flower creek				
Rudiman creek	Muskegon	James Pitt	" 14	2,500
Little Bear creek	"	E. D. Magoon	" 14	7,500
Big bear creek				
Black creek				
Green creek				
Powers creek	Norton & Fruitport	" "	" 14	2,500
Little Black creek	" Muskegon	" "	" 14	2,500
Crockery creek	Ravenna	E. Bartholemew	" 14	2,500
Titatute creek	"	" "	" 14	2,000
Gulley's brook	"	Miles M. Brafford	" 14	3,000
Newaygo:				
Bigelow creek	Brooks	S. D. Thompson	" 14	12,000
Tennewait creek	Croton	" "	" 14	3,000
Thompson creek	Everett	" "	" 14	3,000
Penoyer creek	Garfield	J. K. V. Agnew	" 14	5,000
Williams creek	Garfield & Sheridan	" "	" 14	8,000
Brooks creek	Brooks	W. H. Kritzer	" 14	3,000
Bigelow creek		Edwin O. Shaw	" 14	6,000
Jim Wright creek	Denver	James Stannard	" 14	1,500
Harrington or Heald creek	"	Andrew Gerber	" 14	5,000
Williams creek	Sheridan	" "	" 14	3,000
Pickerel creek	Troy	Chester Brown	" 14	5,000
Cedar creek	"	T. A. Harvey	" 14	3,000
Oakland:				
Shiawassee river	Springfield	F G. Ely	" 8	4,000
Shadbolt creek	Orion and Oakland	Simeon Grube	" 9	4,000
Paint creek	Orion, Oakl'd & Avon	" "	" 9	5,000
Oceana:				
Shigley creek	Hart	E. D. Richmond	" 14	3,000
Russell creek	"	" "	" 14	3,000
Lembrix creek	Golden	" "	" 14	3,000
South br. of Pentwater creek	Elbridge, Hart and Weare	" "	" 14	8,000
Gunnix creek	Elbridge	" "	" 14	3,000
Ogemaw:				
Brooks creek	Rose	Hiram Hodge	April 2	3,000
Wilkins creek	Klacking & Cumming	" "	" 2	3,000
Stream on Sec. 13	Edwards & Ogemaw	G. N. Hauptman	March 22	12,000
Forest Home stream	" "			
Stream on Sec. 12	Edwards	" "	" 22	2,500
Rifle river	Ogemaw	R. H. L'Hommedieu	" 22	12,000
Tittabawassee river	2 N., R. 12	" "	" 22	24,000
Ontonagon:				
Little Cranberry creek	Ontonagon	W. F. Sawyer	May 25	1,000
Union creek	Carp Lake	" "	" 25	1,000
Osceola:				
Narraway creek	Hartwick and Sylvan	J. J. Reik	April 1	2,000
Dock and Tom creeks				
Hicks creek				
Sweets creek	Richmond	Edwin Wood	" 1	4,000
Rattail creek	Orient	F. T. Jeff	" 1	5,000
Benjamin creek	"	" "	" 1	5,000
Sandy creek	"	" "	" 1	5,000
Town Line creek	"	W. B. Stimson	March 28	9,000
Snyder's creek	"	" "	" 28	2,000
Ghost creek	Marion	D. O. Fry	" 28	3,000
Pine river	Bardell	W. B. Stimson	" 28	5,000

Brook Trout Plants, 1895.—CONCLUDED.

County and name of waters.	Township.	Depositor.	Date.	Number.
Otsego:				
East branch of Sturgeon	Corwith	Jas. W. Turner	March 22	5,000
Boyne river	Elmira	W. B. Stimson	“ 28	12,000
Mossback creek	Dover & Livingston	John D. Porter	“ 22	9,000
Brown creek				
Leslie's creek				
Headwaters of Sturgeon river	Livingston	R. H. L'Hommedieu	“ 22	15,000
Pigeon river	Dover	Fred Barker	“ 22	8,000
Black river				
West branch of Sturgeon river	32 N., 3 W.	R. H. L'Hommedieu	“ 22	15,000
Pigeon river and branches	Dover	A. A. Crane	“ 22	12,000
Ottawa:				
Yonker's creek	Holland	Arthur Baumgartel	February 26	2,000
Pine creek	“	J. A. Van Dyke	“ 26	2,000
Pigeon creek	Grand Haven	Frank Myers	March 14	4,000
Robinson creek	Robinson	Frank S. Wilson	“ 14	4,000
Wild's creek	Spring Lake	“ “	“ 14	1,000
Roscommon:				
Sugar creek	Nester	R. H. L'Hommedieu	“ 22	15,000
Sanilac:				
Mill's creek	Worth	Rudolph Pabst	“ 8	3,000
Ellis creek	Lexington	John W. Norman	“ 8	4,000
Shiawassee:				
Coon creek	Sciota, Middleburg & Ovid	James A. Valentine	“ 12	4,000
Alder creek				
St. Clair:				
Silver creek	Greenwood	Paul Willey	“ 8	4,000
St. Joseph:				
Pebble brook	Nottawa	L. A. Clapp	“ 5	2,500
Rocky river	Lakeport & Flowerfield	H. H. Whipple	“ 5	9,000
Portage river	Lakeport & Park	“ “	“ 5	9,000
Stream on Secs. 21, 22 and 28	Summit	Frank Kenyon	February 28	3,000
Tuscola:				
Cass river	Indian Fields & Almer	Charles Montague	April 9	5,000
White creek	Ellington			
Dead creek	Arbela	H. D. Hinkley	“ 5	5,000
Van Buren:				
Ackley creek	Antwerp	Lincoln H. Titus	March 5	3,000
Willow creek	“	B. W. Payne	“ 26	4,000
Hayden creek	Almena	George Langdon	“ 26	5,000
Crystal Spring creek	Porter	C. F. Dey	“ 26	3,000
Headquarters of the Paw Paw river	Antwerp	“ “	“ 26	4,000
Spice Bush creek	Geneva	John C. Merson	“ 25	4,000
Three Mile creek	Bangor & Geneva	Wm. Broadwell, Jr.	“ 25	2,000
Iron Run creek	Paw Paw	C. Engle	“ 26	2,500
Anderson creek	Decatur	Frank Stapleton	“ 26	2,500
Brush creek	Hamilton	“ “	“ 26	5,000
Watkins creek	Geneva	C. D. Stewart	“ 25	2,000
Washtenaw:				
Lett's creek	Sylvan	C. E. Letts	February 14	5,000
Not named	Pittsfield & York	Geo. W. Walterhouse	“ 14	2,000
Paint creek	Ypsilanti & Augusta	“ “	“ 14	2,000
Fleming creek	Superior & Saline	“ “	“ 14	2,500
Townsend creek	Ann Arbor	Emory Townsend	“ 14	6,000
Fleming creek	“ “	Fred R. Rice	“ 14	5,000
Wexford:				
Bock creek	Springville	T. Gale	March 18	3,000
Fletcher creek	“	“ “	“ 18	3,000
Fresh Water creek	Wexford	“ “	“ 18	3,000
Railroad creek	Slagle	James Z. Stanley	“ 19	4,000
Slagle creek	Boon	“ “	“ 19	5,000
Bear creek	Slagle	“ “	“ 19	4,000
Slagle creek	Harrietta & Boon	C. Stein	“ 19	4,000
Newton's creek	Hanover	“ “	“ 19	4,000
Churchill creek	Springville	“ “	“ 19	2,000
Fletcher creek	Antioch	“ “	“ 19	4,000
Cedar creek	Cedar Creek	W. B. Stimson	“ 19	12,000
Total				2,305,000

Brook Trout Plants, 1896.

County and name of waters.	Township.	Depositor.	Date.	Number.
Alcona:				
Duval creek	Mikado	C. W. Luce	March 10	10,000
South branch of Pine river	Curtis	W. M. Featherly	“ 10	20,000
Pine river	Gustin & Mikado	Charles Conklin	“ 10	10,000
Vannettan creek	Harrisville & Mikado	“ “	“ 10	10,000
Buff Brown creek	Hawes	“ “	“ 10	6,000
Black river	Harrisville, Haynes & Alcona	“ “	“ 10	10,000
Sucker creek	Hawes	“ “	“ 10	10,000
Middle branch of Pine river	Mikado	“ “	“ 10	6,000
Mill creek	Harrisville	L. A. Colwell	“ 10	5,000
East branch of Pine river	Gustin	B. Anger	“ 10	15,000
Allegan:				
Barnes creek	Otsego	C. Engel	February 10	3,000
Spencer creek	“	A. A. Mansfield	“ 10	3,000
Blackman creek	Trowbridge	“ “	“ 10	3,000
Mitchell creek	Adams & Otsego	Conrad Bros.	“ 10	10,000
Butternut creek	Otsego	Sherwood Bros.	“ 10	3,000
Burch creek	Alamo	C. R. Rathbun	“ 10	6,000
Rose creek	Otsego	Fred Tubbs	“ 10	3,000
Franklin creek	Otsego & Alamo	A. D. Baker	“ 10	6,000
Pine creek	“ “ “	G. E. Barden	“ 10	9,000
Clear Lake outlet	Trowbridge	Geo. D. Higgins	“ 10	3,000
Deyo's creek	Otsego	John N. Perkins	“ 10	3,000
Yerrick's creek	Otsego & Gun Plains	Chas. W. Edsell	“ 10	6,000
Plummerville creek	Ganges	J. M. Link	“ 5	3,000
Spectacle brook	Monterey	Edwy C. Reid	“ 13	3,000
Bear creek	Monterey & Heath	“ “	“ 13	6,000
Mill creek	Monterey	“ “	“ 13	3,000
Clifford creek	Trowbridge	“ “	“ 13	3,000
Sand creek	Pine Plains	“ “	“ 13	3,000
Doud's creek	Heath	“ “	“ 10	6,000
Sink brook	“	“ “	“ 13	3,000
George's Run	Trowbridge	“ “	“ 13	3,000
Town Line creek	Pine Plains	LaFayette Stuch	“ 13	6,000
Little Rabbit river	Dorr	John C. Newman	“ 13	9,000
Page brook Miller brook	Martin	John Burgess	“ 10	3,000
Rabbit river	Wayland	John A. Turner	“ 10	10,000
Grigg brook	Wayland & Martin	“ “	“ 10	6,000
Abram's creek Travis creek	Alamo	Ed. J. Anderson	“ 10	6,000
Silver creek Seely's creek Brown creek Duncan creek	“	“ “	“ 10	6,000
Delano creek Brown's creek	“	“ “	“ 10	10,000
Alpena:				
Stream on Secs. 31, 32, 33 and 26, and Secs. 3, 11 and 13	Towns 31 and 32	Alex. Cannon, Jr.	March 10	9,000
Antrim:				
Stream on Secs. 6 and 7	Star & Chestonia	Edwin E. Mills	“ 5	6,000
Racket creek	Chestonia	“ “	“ 5	6,000
Cascade creek	“	“ “	“ 5	6,000
St. Mary's creek	Star & Chestonia	“ “	“ 5	3,000
Hillman's creek	Banks	C. S. Campbell	February 27	3,000
Orr creek	“	W. J. Crego	“ 27	3,000
Dwyer creek	“	Jeff Bearrs	“ 27	1,000
Boss creek	“	“ “	“ 27	3,000
Wilson creek	“	“ “	“ 27	1,000
Cedar river and branches	Kearner & Custer	O. W. Kibby	“ 27	15,000
Cold creek	“ “ “	“ “	“ 27	3,000
Crampton creek Wiltse creek Burdick creek Mohrman creek	Central Lake	Chas. E. Ramsey	“ 27	9,000
Ogleton creek	“ “	O. P. Barber	“ 27	6,000

Brook Trout Plants, 1896.—CONTINUED.

County and name of waters.	Township.	Depositor.	Date.	Number.
Baraga:				
Slate river	Avon	N. S. Pennock	May 12	5,000
Ravine river	"	" "	" 12	9,000
Silver river	Baraga	" "	" 12	10,000
Ogema creek	L'Anse	" "	" 12	5,000
Pine creek	Baraga	" "	" 12	6,000
Carp creek	"	" "	" 12	6,000
Sturgeon river		C. D. Sheldon	" 25	16,000
Barry:				
Ream's creek	Hastings	F. H. Barlow	February 13	3,000
Pine Gulley creek	Baltimore	Charles Prichard	" 13	3,000
Leonard's creek	Irving	Luther S. Mills	" 13	1,000
Glass creek	"	" "	" 13	3,000
Silver creek	Yankee Springs	" "	" 13	1,000
Hill creek	Hastings	Jacob H. Neiss	" 13	3,000
Mitchell creek	Irving	" "	" 13	3,000
Stream on Sec. 34	Carlton	R. K. Grant	" 13	1,000
Orr creek	Irving	J. M. McElwain	" 13	3,000
Mill creek	Carlton	" "	" 13	2,000
No name	Rutland	" "	" 13	3,000
Pratt creek	Hastings	A. J. Sponable	" 13	3,000
Stream on Sec. 5	"	" "	" 13	3,000
Glass creek	Rutland	E. G. Holbrook	" 13	3,000
Mangham creek	Baltimore	W. H. Spence	" 13	3,000
Erb creek	Hastings	Edward Schumman	" 13	3,000
Kada creek	Rutland	S. A. Crowell	" 13	3,000
Cherry creek	Hastings	" "	" 13	3,000
Stream on Sec. 31	Burlington	Edgar Fisher	" 13	2,000
High Bank creek	Baltimore	Isaac Powell	" 13	6,000
Griffin creek	Rutland	P. T. Colgrove	" 13	3,000
Heney branch of West creek	"	" "	" 13	3,000
Kenfield creek	Hastings	" "	" 13	3,000
Murphy creek	Hope	A. L. Campbell	" 13	3,000
Stream on Secs. 35 and 36	"	W. J. Lance	" 13	3,000
Polly creek	Barry	Calvin Stanton	" 13	1,000
Britten creek	"	" "	" 13	2,000
Cox creek	Hope	A. Cox	" 13	3,000
Bostwick creek	Barry	C. W. Collins	" 13	3,000
Big Spring brook	"	Jett Letts	" 13	1,000
Quaker brook	Maple Grove	Taylor Walker	" 13	6,000
Mill brook	" "	A. Halfner	" 13	6,000
Salisbury creek	Orangeville	Eli Nichols	" 10	3,000
Not named	"	" "		3,000
Benzie:				
Clay creek	Inland & Homestead	J. K. V. Agnew	February 27	8,000
Platte river	Homestead	W. H. Bennett	April 17	10,000
Aux Bec Scies river	Weldon		" 17	15,000
Little Betsey river	Thompsonville	C. Stein	" 17	9,000
Crystal creek	Benzonia	" "	" 17	3,000
Sherman creek	Inland and Almira	W. H. Schroeder	March 13	6,000
Platte river	" " "	" "	" 13	10,000
Ransom pond and creek	Almira	" "	" 13	3,000
Berrien:				
Brandywine creek	Niles	Geo. W. Dougan	February 11	3,000
Zearning's creek	Galien	D. F. Bommerscheim	" 6	3,000
Warren's creek	Chickaming	" "	" 6	1,000
Estes brook	Buchanan	L. L. Redden	" 6	1,000
Lore creek Lennox creek Penterbaugh creek	Berrien	Henry Frank	" 6	6,000
Lemon creek	Oronoko	George Whitman	" 6	6,000
Farmer's creek	Pipestone and Sodus	E. E. Plimpton	" 5	3,000
Hog or Putnam creek	Sodus and Benton	" "	" 5	3,000
Sand creek	Benton	" "	" 5	6,000
Mill creek	Watervliet	H. E. Morrell	" 5	10,000
Blue creek	Bainbridge & Benton	D. J. Morrison	" 5	9,000
Branch:				
Riley's creek	Sherwood	W. H. Hubbard	" 6	3,000
Miller's Spring brook	Kinderhook	Clayton C. Johnson	March 3	2,000
Stream on Sec. 2	"	Albert J. Dorrance	" 3	1,000
Shinneman's creek	Batavia	Henry H. Barlow	" 3	2,000
Sherman's creek	Coldwater	" "	" 3	3,000

Brook Trout Plants, 1896.—CONTINUED.

County and name of waters.	Township.	Depositor.	Date.	Number.
Calhoun:				
Lenhart's brook	Marshall	J. F. Garwood	February 13	3,000
Pigeon brook	"	" "	" 13	3,000
Pigeon creek	Eckford	" "	" 13	3,000
Hubbard's creek	Marshall	" "	" 13	3,000
Loomis creek	Eckford	" "	" 13	5,000
Pall brook	Battle Creek	Geo. S. Perry	" 13	3,000
Eldred creek	Tekonsha	A. D. Eldred	" 6	6,000
Holmes brook	Athens	Geo. Buchanan	" 6	3,000
Nottawa creek	"	Ira Warsop	" 6	10,000
Buchanan brook	Burlington	" "	" 6	3,000
Thomson's creek	Athens	Joseph Beadle	" 6	6,000
Harsh creek	Burlington	Cyrenius B. Knight	" 6	3,000
Cass:				
Smith's creek	Jefferson & Howard	C. H. Kimmerle	" 6	6,000
Jones creek	La Grange	" "	" 6	3,000
Stream on Secs. 24 and 25	Jefferson	Edward Kegan	" 6	5,000
Stream on Secs. 27, 28 and 33	La Grange	A. M. Kingsbury	" 6	3,000
Wither's creek	Porter	J. Withers	" 6	10,000
Motley's run	"	Geo. E. Everding	" 6	1,000
Stream on Secs. 30, 31, 32 and 33	Newberg	Chas. Wetherbee	" 6	1,000
Dowagiac creek	Volinia	C. S. Jones	March 3	6,000
Spring brook	Newberg	" "	" 3	1,000
Big creek	Marcellus	W. L. Arnold	" 3	6,000
Cobert creek Brandywine creek	Jefferson and Melton	J. A. Parsons	" 3	3,000
Conklin creek	Marcellus	E. P. McKenzie	" 3	3,000
Mechanicsburg creek	La Grange	A. B. Atwater	" 3	6,000
Charlevoix:				
Spring brook br. of Bear creek	Melrose	W. B. Stimson	April 4	10,000
St. Clair creek	South Arm	C. S. Campbell	February 27	3,000
Monroe creek	" "	L. D. Bartholemew	" 27	10,000
Cheboygan:				
Little Pigeon river	Nunda	Jacob K. Shook	March 6	10,000
Spring brook	Burt	Wm. Hawkins	" 6	3,000
Little Sturgeon river	34 and 35 N., 2 W.	M. A. McHenry	" 6	10,000
Stewart creek	33 N., 2 W.	R. H. L'Hommedieu	" 21	12,000
Chippewa:				
East br. of Tahquamenon river	46 N., 7 W.	Mich. Fish Com.	May 8	13,000
Trout brook	Rudyard	John H. D. Everett	" 6	4,000
Bear creek	"	" "	" 6	4,000
Trout brook	"	H. H. Wyatt	" 6	7,000
Sault Rapids		Mich. Fish Com.	April 10 to June 29	216,000
Clare:				
Randall creek	Grant	O. S. Derby	February 17	3,000
Becker creek	"	" "	" 17	3,000
Chard creek	"	" "	" 17	6,000
Waldo creek	"	" "	" 17	3,000
Hay creek	"	" "	" 17	3,000
Beaver creek	"	" "	" 17	6,000
Utley creek Wagner creek	Surrey	Nat D. Watkins	" 17	6,000
No name	"	" "	" 17	3,000
Newton creek	"	E. H. Smith	" 17	3,000
Several streams on Secs. 8, 9, 16, 20 and 32	17 N., 4 W.	Geo. M. Brown	March 20	6,000
Silver creek	17 N., 6 W.	" "	" 20	6,000
Norway creek	Temple	C. Stein	April 17	6,000
Gishawash creek	"	" "	" 17	6,000
Clinton:				
Coon creek	Middleburg & Siota	J. A. Valentine	February 21	6,000
Little Maple river	Ovid	F. D. Cleveland	" 21	5,000
Alder creek	Ovid and Victor	Chas. Cowan	" 21	3,000
Meadow brook	Eagle	Frank O. Bryan	" 18	3,000
Crawford:				
North branch of Au Sable	28 N., 1 W.	R. H. L'Hommedieu	March 21	18,000
East " " "	27 N., 3 W.	" "	" 21	15,000
Br. of south br. of Au Sable	Center Plains	" "	" 21	15,000
East br. of east br. of Au Sable	Grayling	A. E. Newman	" 6	10,000

Brook Trout Plants, 1896.—CONTINUED.

County and name of waters.	Township.	Depositor.	Date.	Number.
Delta:				
Day's river	Masonville and Baldwin	Richard H. Mertz	May 6	6,000
Dickinson:				
Stream on Secs. 6, 41 and 27	Breen	S. H. Bridges	“ 15	9,000
Davis creek	Breen and others	“ “	“ 15	6,000
Eaton:				
Mill creek	Walton and Lee	Samuel Curtis	February 21	10,000
Town Line brook	Walton and Carmel	E. R. Moran	“ 21	5,000
Boyer brook	Chester	F. S. Jordan	“ 13	3,000
Roll brook	“	“ “	“ 13	3,000
Jennie or Beeman brook	“	“ “	“ 13	3,000
Hanes creek	Vermontville	“ “	“ 13	3,000
Jordan brook	Chester	“ “	“ 13	3,000
Emmet:				
Bear river	Clarion	W. B. Stimson	April 4	10,000
Maple river	Pellston	“ “	“ 4	16,000
Genesee:				
Begole's creek	Genesee	C. M. Begole	February 18	6,000
Gladwin:				
Chapman creek	Edward and Clement	Geo. L. Lamb	March 6	6,000
Gogebic:				
McDonald river	Bessemer	L. L. Wright	May 7	10,000
Siemers creek	Ironwood & Bessemer	“ “	“ 7	8,000
Welch creek	Ironwood	“ “	“ 7	6,000
Not named	“	“ “	“ 7	6,000
Hammond's creek	“	“ “	“ 7	6,000
Montreal river	“	“ “	“ 7	6,000
Black river	Bessemer	“ “	“ 7	4,000
Little Presque Isle river	Wakefield	“ “	“ 7	10,000
East branch of Little Presque Isle river	Marenisco	“ “	“ 7	4,000
Stream on Secs. 9, 16 and 17	46 N., 43 W.	“ “	“ 7	2,000
Little Presque Isle river	Marenisco	“ “	“ 7	6,000
Duck creek	Watersmeet	“ “	“ 7	4,000
Ontonagon river	“	“ “	“ 7	4,000
Trout brook	Marenisco	J. M. Whitman	“ 7	2,000
Slate river	“	“ “	“ 7	7,000
Trout brook	“	Henry B. Roney	“ 7	6,000
Pelton brook	“	“ “	“ 7	2,000
Powder Mill creek	Bessemer	Thos. Kissane	“ 7	4,000
No name on fract. Secs. 8 and 9	Ironwood	“ “	“ 7	4,000
Welch creek	“	L. C. Walker	“ 7	2,000
Duck creek	Watersmeet	A. D. Johnston	“ 7	4,000
Ontonagon river	“	“ “	“ 7	4,000
Black river	Bessemer	L. L. Wright	“ 7	14,000
Montreal river	Ironwood & Bessemer	“ “	“ 7	14,000
Grand Traverse:				
Beitner creek	Blair	J. K. V. Agnew	February 27	6,000
Boardman river		L. L. Lydell	“ 27	20,000
Mill creek Keiser's creek		“ “	“ 27	3,000
Fairbank creek	Whitewater	“ “	“ 27	3,000
East creek	Paradise	J. O. Crotser	March 13	6,000
Mayfield creek	“	“ “	“ 13	6,000
Gratiot:				
Adams creek	Arcada, Seville and Sumner	Birton I. Gee	“ 10	6,000
Bullock creek	Sumner	“ “	“ 10	3,000
Hillsdale:				
Wheatland creek	Wheatland	James B. Thorne	“ 3	3,000
Silver creek	Cambria and Woodbridge	Ed. D. Babcock	February 13	3,000
Stream on Secs. 14 and 23	Camden	W. C. Young	“ 13	3,000
Stream on Secs. 11, 12, 36, 26, 22, 28 and 17	Reading and Allen	Chas. F. Niblack	“ 13	6,000
Hodges creek	Scipio	T. J. Strait	“ 13	3,000
Townsend Spring brook	Moscow and Hanover	Eugene Strait	“ 13	3,000

Brook Trout Plants, 1896.—CONTINUED.

County and name of waters.	Township.	Depositor.	Date.	Number.
Houghton:				
Otter creek and branches	Portage and Chassell	C. D. Sheldon	May 25	30,000
Salmon Trout river	Portage	" "	" 25	14,000
Martin creek	Calumet	A. Martin	" 12	3,000
Hill's creek	Houghton & Keweenaw	Wm. H. Ellis	" 12	6,000
Bad Water creek	Duncan	G. W. Shane	" 12	3,000
Shane creek	"	" "	" 12	6,000
Blackman creek	"	" "	" 12	6,000
Sidnaw creek	47 N., 35 W.	Geo. H Houser	" 12	6,000
Breauno river	Laird	Leonard Gillispie	" 12	6,000
Branch of west branch of Sturgeon river	"	" "	" 12	9,000
Huron:				
Willow Spring brook	Verona	J. B. Madill	March 17	6,000
Ionia:				
Seeley's creek	Otisco and Grattan	G. O. Bignell	February 15	10,000
Stocking's creek and Cannon's Mill pond	Otisco	H. J. Leonard	" 15	3,000
Froyer creek Silver creek McVeigh creek	Lyons	Fremont C Hathaway	" 21	10,000
West creek	"	Albert Roof	" 21	3,000
Erret creek	"	" "	" 21	3,000
Stone Quarry creek	"	" "	" 21	3,000
Knapp creek	"	" "	" 21	3,000
Struble creek	Lyons and No. Plains	" "	" 21	3,000
Brown creek	Lyons	" "	" 21	3,000
Ronald creek	Ronald	H. L. Bailey	" 21	6,000
Iosco:				
Sim's creek	Tawas and Baldwin	C. W. Luce	March 10	6,000
East branch of Au Gres river	Plainfield, Grant and Sherman	" "	" 10	20,000
Gailey creek	Plainfield	" "	" 10	10,000
Smith's creek	Plainfield, Grant and Sherman	" "	" 10	10,000
Indian creek	Oscoda	John Tadgahsong	" 10	10,000
Iron:				
West branch of Jumbo river	46 N., 37 W.	G. W. Shane	May 12	6,000
Jumbo river	" "	" "	" 12	6,000
Isabella:				
Skunk creek	Rolland	W. R. Jones	February 15	15,000
" "	"	J. K. V. Agnew	" 15	10,000
Pumphrey creek	"	" "	" 15	5,000
Hersey creek	Wise	E. W. Allen	" 17	6,000
Loomis creek	"	" "	" 17	6,000
Willey creek	"	" "	" 17	6,000
Stoney brook	Deerfield	Geo. A. Hicks	March 10	3,000
Chippewa Cedar creek	"	" "	" 10	6,000
Darrough creek	Union	" "	" 10	6,000
Camfro creek	Deerfield	" "	" 10	3,000
Wheelan's creek	Union	Geo. A. Chatterton	" 10	6,000
Jackson:				
Cleland stream	Hanover	W. W. Dew	February 13	3,000
Mackey brook	Rives	Grove H. Wolcott	" 13	3,000
Tributary to Grand river	Liberty	C. J. Van Schoick	" 13	3,000
Wheaton spring	Hanover	E. L. Heath	" 13	2,000
Kalamazoo:				
Eagle or Streator creek	Charleston and Ross	Henry D. Streator	" 13	5,000
Hinton creek	Ross	H. Dale Adams	" 13	6,000
Little Portage creek	Texas & Kalamazoo	A. J. Stevens	" 10	3,000
No name		A. L. Lakey	" 10	3,000
Asylum brooks	Kalamazoo	Henry Ostrander	" 10	3,000
Harrison's creek	Schoolcraft	W. C. Kohl	March 3	1,000
Wells creek	"	" "	" 3	1,000
Little Portage creek	Wakeshma	C. S. Hasbrouck	" 3	6,000
Terry creek	Prairie Ronde	John Terry	" 3	6,000
Klein creek	Flowerfield	Chas. W. D. Allen	" 3	6,000
Chamberlain creek	Prairie Ronde	John E. Pabst	" 3	6,000
Bly creek	" "	Henry I. Allen	" 3	6,000
Stanley creek	Portage	Joseph Conklin	" 3	1,000

Brook Trout Plants, 1896.—CONTINUED.

County and name of waters.	Township.	Depositor.	Date.	Number.
Kalkaska:				
Rapid river	Clearwater, Kalkaska and Excelsior	Elmer E. Wealch	February 27	10,000
South Boardman river	Boardman	W. B. Stimson	April 4	10,000
Middle Boardman river	"	" "	" 4	10,000
Rapid river	Rapid River	" "	" 4	25,000
Kent:				
Hutchins creek	Algoma & Plainfield	Robert Carlyle	February 10	2,000
Barclay creek Leache creek	Cannon & Plainfield	" "	" 10	3,000
Turner creek	Algoma	" "	" 10	2,000
Keweenaw:				
Montreal river		W. T. Ellis	May 25	26,000
Silver creek	Allouez	" "	" 12	6,000
Gratiot river	"	Charles Schmick	" 12	1,000
Tobacco river	Sherman	Morgan Williams	" 12	10,000
Lake:				
Streams on Secs. 10, 11 and 12	Centre	J. K. V. Agnew	February 27	6,000
Roach creek	"	" "	" 27	6,000
Irons creek	Eden and Elk	" "	" 27	12,000
Little Danaher creek	Plains	" "	" 27	5,000
Sauble river	Sheridan and Elk	H. W. Marsh	March 23	15,000
Little Manistee river	19 N., 13 W.	Geo. M. Brown	" 23	15,000
North branch	19, 20 N., 12 W.	" "	" 23	6,000
Little Manistee river	Ellsworth	W. B. Stimson	April 4	15,000
N. br. of Pere Marquette river	Nirvana	Mich. Fish Com.	" 13	10,000
Lapeer:				
Hasly creek	Elba and Oregon	L. J. Wicker	February 18	9,000
Elk creek	Marathon	J. L. Preston	" 18	6,000
North branch of Flint river	Rich	" "	" 18	10,000
Smith's creek	Deerfield	" "	" 18	6,000
Dutch creek	Oregon	Hiram Jones	" 18	3,000
Brocker creek	Hadley	M. F. Hemingway	" 18	3,000
Webster creek	"	" "	" 18	6,000
Hemingway creek	"	" "	" 18	3,000
Farmer's creek	Metamora	R. B. Conklin	" 18	10,000
Branch of Hunter's creek	Lapeer	C. A. Smith	" 18	3,000
Gravel creek	North Branch	Jephtha Bradshaw	April 6	9,000
Leelanau:				
Mosseau's creek	Leelanau	Omena Hotel Assoc.	March 13	6,000
Stream and pond on Secs. 4, 32, 4, 31	"	N. E. De Golier	" 13	6,000
Crystal river	Glen Arbor	D. H. Day	" 13	6,000
Cedar creek	Solon	N. W. Herrington	" 13	6,000
Singery creek Everett's creek Clear creek	"	" "	" 13	6,000
Wells creek	Kasson	N. W. Courson	" 13	1,000
Knox creek	Empire	E. R. Dailey	" 13	1,000
Lenawee:				
Woodward creek	Franklin	H. H. Holladay	" 3	3,000
Evans creek	Franklin & Tecumseh	M. J. Pierce	" 3	8,000
Lawrence creek	Hudson	James B. Thorn	" 3	3,000
Luce:				
Stream on Secs. 26, 5, 8, 17, 16 and 21	Columbus	W. L. Lake	May 11	6,000
Macomb:				
McKay's creek	Bruce	H. W. Bradley	February 18	6,000
Mackinac:				
Coleman creek	Garfield	Wm. Hudson	May 6	2,000
Cool creek	"	" "	" 6	2,000
Stevens creek	Newton	E. A. Davis	" 6	2,000
Outlet of S. Manistique lake	"	" "	" 6	2,000
Manistee:				
Little Bear creek	Springdale	J. K. V. Agnew	February 27	6,000
Pine creek	Stronach	" "	" 27	10,000
Corfu creek	Brown	" "	" 27	4,000

Brook Trout Plants, 1896.—CONTINUED.

County and name of waters.	Township.	Depositor.	Date.	Number.
Manistee—*Continued:*				
Conger Creek	Maple Grove	J. K. V. Agnew	February 27	10,000
Knickerbock creek Gilson creek	Maple Gr've & Marilla	M. S. Howes	March 13	10,000
John P. Mason creek	Onekema	Hans Hansen	“ 13	6,000
Secor's creek	Manistee	Thomas H. Peterson	“ 20	3,000
Clay Bank creek	East Lake	T. A. Brown	“ 20	9,000
Kill or Kinne creek	Brownstown	C. Stein	April 17	2,000
Marquette:				
Little Falls creek	Republic	Peter Pascoe	May 12	6,000
Second river	Ely & Humboldt	W. L. Bedford	“ 12	6.000
North branch of west branch of Escanaba river	Tilden & Palmer	Geo. A. Newett	“ 12	9,000
Cook's creek	Ishpeming	“ “	“ 12	3,000
Switzer's creek	Richm'd & Negaunee	John Q. Adams	“ 12	10,000
Mason:				
Nickerson creek	Summit	D. C. Wickham	February 24	6,000
Quinn creek	Summit & Riverton	“ “	“ 24	6,000
Lincoln creek	19 N., 15 W.	Geo. M. Brown	March 23	6,000
Big Sable creek	20 N., 15 W.	Wm. H. Baldwin, Jr.	“ 23	15,000
Mecosta:				
Black creek	Millbrook	J. K. V. Agnew	February 15	6,000
Bamber brook	Sheridan	“ “	“ 15	5,000
Randy branch	Martiny & Chippewa	“ “	“ 15	12,000
Hughes creek	Martiny	“ “	“ 15	7,000
Pointer creek	Wheatland & Norton	“ “	“ 15	4,000
Little Chippewa river	Sheridan	“ “	“ 15	8,000
Randy branch	Chippewa	James A. Roof	“ 15	3,000
Stream on Secs. 20 and 17	“	“ “	“ 15	2,000
Cedar creek	Grant	“ “	“ 15	6,000
Gill creek	Deerfield	Fred C. Boyd	March 2	6,000
Quigley creek	“	“ “	“ 2	10,000
Stony creek	“	“ “	“ 2	6,000
Mack's creek		Wm. B. Stimson	April 9	7,000
Little Muskegon river	Deerfield	“ “	“ 9	15,000
Borland creek	Ætna	“ “	“ 9	10,000
Paris creek	Green	L. S. Sniger	“ 9	15,000
Midland:				
Pine river	Homer, Porter and others	Wm. Booth	“ 6	25,000
Missaukee:				
Clane creek	Lucas	D. B. Kelley	March 12	20,000
Montmorency:				
Brush creek	Montmorency	James Hubert	“ 11	15,000
Montcalm:				
Corbou creek		Birton I. Gee	“ 10	6,000
Town Line Lake creek	Belvidere	J. K. V. Agnew	February 15	8,000
Tamarack creek	Winfield and Cato	“ “	“ 15	20,000
Brand creek	Winfield	Frank J. Rossman	“ 15	3,000
Lahar creek	Home	W. R. Jones	“ 15	10,000
Two east br. of Cedar creek	Day	Jacob McCrea	“ 15	10,000
Spring creek	Day and Ferris	S. Frost	“ 15	5,000
Eutrecan creek	Douglass	C. E. Elliott	“ 15	6,000
Alder creek	Sidney	“ “	“ 15	6,000
Big Spring creek	Pine	Fred Spooner	“ 15	3,000
Curtis creek	“	“ “	“ 15	10,000
West branch of Flat river	“	“ “	“ 15	6,000
“ “ “ “ “	“ & Montcalm	S. J. Youngman	“ 15	10,000
Irving creek	“	“ “	“ 15	16,000
Wiley creek	“ Cato & Douglass	“ “	“ 15	10,000
Riches creek	Cato & Belvidere	“ “	“ 15	8,000
Stream on Secs. 21, 23 and 27	Pine	“ “	“ 15	3,000
Bushley creek	Cato & Winfield	“ “	“ 15	8,000
Clifford creek	Montcalm	T. I. Phelps	“ 15	3,000
Wilcox creek	Eureka	“ “	“ 15	3,000
Spring brook	“	“ “	“ 15	3,000
Salt Spring brook	“	“ “	“ 15	3,000
Horse Shoe creek	Montcalm	“ “	“ 15	3,000

Brook Trout Plants, 1896.—CONTINUED.

County and name of waters.	Township.	Depositor.	Date	Number.
Muskegon:				
Stahl creek	Fruitport	Edwin C. Torrans	Feb. 24	3,000
Vincent creek	"	" " "	" 24	6,000
Mitchell creek Roswell creek	Ravenna	Miles W. Bradford	" 24	6,000
Gordon creek	Muskegon & Fruitp't	G. S. Gordon	" 24	3,000
Rudiman creek	" " "	James Pett	" 24	3,000
Big Black creek	Moreland & Eggleston	E. D. Magoon	" 24	6,000
Power's creek	Norton & Fruitport	" "	" 24	3,000
Little Black creek	Norton & Muskegon	" "	" 24	3,0 0
Big Bear creek	" " "	" "	" 24	6,000
Silver creek Thomson's creek Flower creek	Whitehall	E. M. Ruggles	" 24	5,000
Cleveland creek	Blue Lake	John Haverkate	" 24	10,000
Crockery creek and tributaries	Casnovia	Elliot T. Slocum	Mar. 17	5,000
Newaygo:				
Jim Wright creek	Denver	James Stannard	Feb. 29	3,000
Harrington or Heald creek	"	Andrew Gerber	" 29	3,000
Odell creek	Sherman & Dayton	Frank E. Cole	" 29	3,000
William's creek	Sheridan & Garfield	" " "	" 29	3,000
Cushman creek	Dayton & Greenwood	J. A. Gerber	" 29	6,000
Brook's creek	Sheridan & Bridgeton	W. D. Sargeant	" 29	10,000
Bigelow creek	Brooks	Edwin O. Shaw	Mar. 17	6,000
" "	"	S. D. Thompson	" 17	15,000
William's creek	Garfield & Sheridan	J. K. V. Agnew	" 17	8,000
Penoyer creek	" " "	" "	" 17	5,000
Mehrten's creek	Wilcox	" "	" 17	9,000
Head of Rouge river	Croton	George King	" 17	3,000
White river	Wilcox	M. D. Hayward	" 17	15,000
Lower Cold creek	Lincoln	" "	" 17	6,000
Five Mile creek	Wilcox	" "	" 17	6,000
Flinton creek	"	" "	" 17	9,000
Minnie creek	Lincoln	" "	" 17	6,000
Stream on Secs. 3, 10, 15 and 16	Wilcox	" "	" 17	6,000
Upper Cold creek	Lincoln	" "	" 17	6,000
S. br. of Pere Marquette river	Lilly	Michigan Fish Com.	April 13	25,000
Pea's creek		" " "	" 13	10,000
Grass Lake creek		" " "	" 13	5,000
Baker creek		" " "	" 13	5,000
Oakland:				
Branch of Rouge river	Bloomfield	S. Alexander	Feb. 21	6,000
Kearsley creek	Groveland	L. J. Winder	" 18	10,000
Oceana:				
Cedar creek	Crystal, Weare and Pentwater	D. C. Wickham	" 24	10,000
Annley creek	Weare	" "	" 24	3,000
Stoney creek		O. B. Estey	" 24	3,000
Flower creek		" "	" 24	3,000
Genneux creek	Elbridge	E. D. Richmond	" 24	3,000
Lennox creek	Golden	" "	" 24	3,000
Stony creek	Shelby and Benona	J. K. Flood	" 24	6,000
North branch of White river	Ferry and Leavitt	" "	" 24	10,000
S. branch of Pentwater river	Pentwater and others	" "	" 24	10,000
Russell creek	Hart	" "	" 24	3,000
N. branch of Pentwater river	Weare and Crystal	" "	" 24	15,000
Shigley creek	Hart	" "	" 24	3,000
Headwaters of north branch of White river	Newfield	Wm. Hayward	" 29	6,000
Ogemaw:				
Stream on Sec. 12	Edwards	G. A. Hauptman	Mar. 6	3,000
Stream on Sec. 13 Forest Home stream	Edwards & Ogemaw	" "	" 6	15,000
Nester Creek	Logan	John R. McDonald	" 10	10,000
Rifle river	Ogemaw	R. H. L'Hommedieu	" 21	15,000
Tittabawassee river	21 N., 1 E.	" "	" 21	20,000
Osceola:				
Sweet's creek	Richmond	Edwin Wood	Feb. 17	5,000
Isaacson creek	Richmond & Lincoln	J. W. Densmore	Mar. 23	6,000
Hersey river	Richmond	" "	" 23	15,000
Johnson's creek	"	" "	" 23	6,000
Snyder's creek	Lincoln	W. B. Stimson	April 4	6,000
Town Line creek	"	" "	" 4	6,000
East tributary of Pine river	Sherman	Charles Larson	Mar. 5	6,000

Brook Trout Plants, 1896.—CONCLUDED.

County and name of waters.	Township.	Depositor.	Date.	Number.
Osceola—*Continued:*				
Hunell creek	Harmon	Ezekiel Marsh	March 10	10,000
Armstrong creek	Mentor	Peter Cauchy	" 10	6,000
Pine river	Burdell	W. B. Stimson	April 4	15,000
Otsego:				
Chapin's creek	Corwith	D. M. Sly	March 6	15,000
Pigeon river and branches	Dover	A. A. Crane	" 6	15,000
Lakes on Secs. 22, 27 and 28	"	John Goslow	" 6	3,000
Mossback creek	Dover & Livingston	John D. Foster	" 6	10,000
Brown creed				
Leslie's creek				
East branch of Sturgeon river	Corwith	James W. Turner	" 6	6,000
West branch of Sturgeon river	Elmira	R. H. L'Hommedieu	" 21	15,000
Headwaters of Sturgeon river	Livingston	" "	" 21	15,000
Boyne river	Elmira	W. B. Stimson	April 4	12,000
Ottawa:				
Waverly brook	Holland	A. G. Baumgartel	February 5	3,000
Bertsch's creek	"	" "	" 5	3,000
Stream on Secs. 13, 16 and 21	Talmadge	Geo. H. Root	" 24	3,000
Crockery creek	Chester	Robert Lange	March 17	6,000
Roscommon:				
Sugar creek	Nester	R. H. L'Hommedieu	" 21	15,000
Schoolcraft:				
Spring creek	Germfask	Edward Menere	May 11	3,000
Mead creek	"	" "	" 11	6,000
Bear creek	"	" "	" 11	6,000
St. Joseph:				
Houston's run	Fawn River	Alex. Houston	March 2	3,000
Stream on Secs. 5, 8 and 17	" "	Freeman L. Miller	" 3	3,000
Spring run	Flowerfield	P. C Pursel	" 3	3,000
Rocky river	Flowerfield & Lockport	H. H. Whipple	February 6	10,000
Portage river	Park and Lockport	" "	" 6	10,000
Pebble brook	Nottawa	L. A. Clapp	" 6	3,000
Tuscola:				
Dead creek	Arbela	H. D. Hinkley	" 18	6,000
Gooden creek	Vassar	M. Brainard	" 18	10,000
Van Buren:				
Campbell's creek	Almena	Charles Veley	" 11	3,000
Hale's spring brook	"	" "	" 11	3,000
Carter's creek	Pine Grove	A. B. Stuck	" 10	6,000
Brush creek	Lawrence	George McFern	" 11	10,000
East branch of Paw Paw river	Antwerp	J. W. Frie	" 11	10,000
Willow creek	"	B. W. Payne	" 11	5,000
Hayden creek	Almena	George Langdon	" 11	6,000
Brush creek	Hamilton	Frank Stapleton	" 11	6,000
Anderson creek	Decatur	" "	" 11	3,000
Butternut creek	Geneva	W. O. Cook & Son	" 11	6,000
Deer Lick creek	South Haven	" " "	" 11	3,000
Iron run	Paw Paw	C. Engle	" 11	3,000
Ackley brook	Antwerp	Lincoln H. Titus	" 11	3,000
Tributary to north branch of Paw Paw river	Paw Paw	William M. Thayer	" 11	6,000
Washtenaw:				
Fleming's creek	Ann Arbor	Fred R. Rice	" 6	6,000
Townsend creek	" "	Emery Townsend	" 6	6,000
Fleming creek	Superior and Saline	Geo. W. Walterhouse	" 6	3,000
Lett's creek	Sylvan	C. E. Letts	" 6	6,000
Wexford:				
Fletcher creek	Antioch	C. Stein	April 17	3,000
Newton's creek	Hanover	" "	" 17	3,000
Churchill creek	Springville	" "	" 17	3,000
Slagel creek	Boon	" "	" 17	10,000
Cedar creek	Cedar Creek	W. B. Stimson	" 4	12,000
Total				3,367,000

Brown Trout Plants, 1895.

County and name of waters.	Township.	Depositor.	Date.	Number.
Chippewa:				
Sault Ste. Marie river	Sault Ste. Marie	Michigan Fish Commission	April 29	5,000
Clare:				
Bear Lake	17 N., 5 W.	Geo. M. Brown	" 1	10,000
Grand Traverse:				
Boardman river	Several	L. L. Lydell	" 15	5,000
Ionia:				
Kelsey's creek and pond	Ionia	E. P. Kelsey	March 12	10,000
Kalamazoo:				
Campbell creek	Richland and Comstock	H. Dale Adams	" 4	5,000
Gunn creek	Charleston			
Whitford lake	"			
Lake:				
Twin lakes	Webber	Geo. M. Brown		15,000
Star lake	Lake	" "		20,000
Middle branch of Pere Marquette river	Yates and others	W. C. Rowley		7,000
L lake	Pleasant Plain	T. E. Borden		10,000
Bray lake	" "	" "		10,000
Crandall lake	" "	" "		10,000
Wolf lake	Center	Wm. H. Baldwin, Jr.		15,000
Macomb:				
Silver creek and tributaries Thornton lake and tributaries	Bruce & Washington	H. W. Bradley	March 8	7,500
Marquette:				
Dead river	Marquette	J. M. Longyear	May 22	10,000
Montcalm:				
Fatte lake	Eureka	T. I. Phelps	February 20	7,500
Muskegon:				
Carleton creek	Whitehall	John H. Chapman	March 14	5,000
Newaygo:				
South branch of Pere Marquette river	Several	A. B. Atwater	" 18	20,000
Oceana:				
Colfax lake	Colfax	E. D. Richmond	" 14	7,000
Ogemaw:				
Devoe lake	Cummings	A. S. Rose	April 2	5,000
Ontonagon:				
Fire Steel river	Greenland	Willis F. Sawyer	" 28	15,000
Mecosta:				
Clear lake	Colfax	Geo. A. Roof	February 19	7,000
Total				206,000

Brown Trout Plants, 1896.

County and name of waters.	Township.	Depositor.	Date.	Number.
Berrien:				
Ox creek Eastman creek	Benton and Sodus	E. E. Plimpton	April 9	3,000
Pipestone creek	Pipestone and Sodus	“ “	“ 9	10,000
Gratiot:				
Adams creek	Arcada & Pine River	Birton I. Gee	March 10	6,000
Beaver creek	Seville	“ “	“ 10	6,000
Hillsdale:				
Spring brook	Woodbridge	W. Whitney	February 13	3,000
Huron:				
Cass river	Sheridan	John B. Madill	March 17	10,000
Pigeon creek	“	“ “	“ 16	6,000
Ionia:				
Kelsey creek	Ionia	H. L. Bailey	February 21	3,000
Choater Spring brook	Liberty	R. C. Cary	“ 13	3,000
Kalamazoo:				
Bear creek	Wakeshma	Wm. Fulton	March 3	6,000
Portage creek	Charleston & Climax	Barzilla Snow	“ 26	10,000
Capt. Child's creek	Climax and Pavilion	H. Dale Adams	February 13	10,000
Kent:				
Farr creek	Spencer and Oakfield	Freeman Addis	“ 10	3,000
Butternut creek	Spencer	“ “	“ 10	5,000
Stream on Sec. 17	Cascade	Lewis M. Lester	“ 10	3,000
Seder creek	Algoma	C. C. Darling	March 17	6,000
Blue lake	Oakfield	T. I. Phelps	February 15	6,000
Rush creek	Wyoming	Vernon Hooper	“ 13	6,000
Lake and Mason:				
Sauble river	Sheridan and Elk	H. W. Marsh	March 23	10,000
Lenawee:				
Wolf creek	Cambridge & Adrian	Marion A. Ladd	“ 3	10,000
Macomb:				
Silver creek Smith's creek	Bruce & Washington	H. W. Bradley	February 18	6,000
Elliot's creek	Bruce	“ “	“ 18	6,000
Muskegon:				
Big Black creek	Moorland and Muskegon	Ernest Eimer	“ 24	10,000
Oakland:				
Paint creek and tributaries	Avon, Oakland and Orion	Simon Grube	April 6	15,000
Osceola:				
Ashton creek	Lincoln and Leroy	J. W. Densmore	March 23	10,000
Rose lake outlet	Sherman	E. R. Fernstrom	“ 5	6,000
Ottawa:				
Rush creek	Blendon	Wm. Hall	February 24	3,000
St. Joseph:				
Little Portage creek	Mendon	C. L. Hasbrouck	March 3	10,000
Mill creek	Constantine	Arthur N. Culp	February 6	10,000
School creek	Flowerfield	H. H. Whipple	“ 6	9,000
Hog creek	Lockport	“ “	“ 6	10,000
Total				220,000

Rainbow Trout Plants, 1895.

County and name of waters.	Township.	Depositor.	Date.	Number.
Crawford:				
Big creek	2 N., 1 W.	R. H. L'Hommedieu	June 16	15,000
Houghton:				
Pilgrim river	Portage and Adams	C. D. Sheldon	May 24	12,000
Lake:				
Baldwin creek	Webber	Michigan Fish Commission	June 10	5,000
Tributary to Little Manistee	Centre	J. K. V. Agnew	" 21	5,000
Mecosta:				
Cheney creek	Greene	Michigan Fish Commission	July 1	3,000
Newaygo:				
South branch of Pere Marquette river	Several	Michigan Fish Commission	June 17	15,000
Ontonagon:				
Town Line creek	Ontonagon	W. F. Sawyer	May 2	8,000
Osceola:				
East and west branches of Pere Marquette river	Several	Michigan Fish Commission	June 7	5,000
Total				68,000

Rainbow Trout Plants, 1896.

County and name of waters.	Township.	Depositor.	Date.	Number.
Crawford:				
Big creek	2 N., 1 W.	R. H. L'Hommedieu	June 3	15,000
Lake:				
Middle branch of Pere Marquette river	Nirvana	Michigan Fish Commission	" 15	5,000
Macomb and Lapeer:				
North branch of Clinton river	Bruce and Almont	H. W. Bradley	" 3	10,000
Manistee:				
Sauble river	Sheridan and Elk	H. W. Marsh	May 25	15,000
Mecosta:				
Stream on Secs. 20 and 21	Deerfield	Fred C. Boyd	June 8	5,000
Total				50,000

Wall-eyed Pike Plants, 1896.

County.	Name of waters.	Depositor.	Date.	Number.
Barry	Gilkie lake	Addison Pennock	May 15	120,000
	Stewart lake	L. M. Bugbee	" 15	120,000
	Mud lake	Dugall Campbell	" 15	120,000
	Wall lake	W. D. Hayes	" 15	120,000
	Clear lake	Frank Mattison	" 15	120,000
Berrien	Clear lake	Charles Fuller	" 11	120,000
Calhoun	Turtle lake	C. A. Zimmerman	" 13	160,000
	Lake Goguac	F. W. Deming	" 11	120,000
	Montcalm lake	James K. O'Hara	" 11	120,000
Cass	Sky-hawk lake	C. S. Jones	" 14	120,000
	Huycks lake	" "	" 14	120,000
	Fish lake	W. L. Arnold	" 14	120,000
	Hemlock lake	E. S. Mack	" 14	120,000
	Otter lake	W. B. Young	" 14	120,000
	Carver's lake	John A Parsons	" 14	120,000
	Luce lake	Theo. H. Zintgraff	" 14	120,000
	Spring lake	Edgar Wetherbee	" 13	160,000
	Lilla lake	Albert Bogert	" 13	160,000
	Diamond lake	B. L. Rudd	" 13	160,000
Eaton	Long lake	W. L. Freemire	" 15	120,000
	Sebewa lake	" "	" 15	120,000
Hillsdale	Bear lake	Wm. C Kemp	" 14	120,000
	Baw Beese lake	" "	" 14	120,000
Jackson	Liberty pond	Reid C. Cary	" 14	120,000
	Clarke's lake	John L. De Lamater	" 14	80,000
	Fox lake	Wells W. Dew	" 14	120,000
	Round lake	Chas. J. Van Schoick	" 14	120,000
	Gillett's lake	Vernon Sullivan	" 11	120,000
Kalamazoo	Sugar Loaf lake	W. C. Kohl	" 14	120,000
Kent	Reed's lake	Consolidated Railway Co.	" 12	160,000
	Chain lake	C. C. Darling	" 12	160,000
	Long lake	" "	" 12	160,000
	Pickerel lake	" "	" 12	160,000
	Round lake	" "	" 12	160,000
	Camp lake	" "	" 12	160,000
	Skelly lake	H. A. Lamb	" 12	80,000
	Chapin lake	W. P. Hetherington	" 12	80,000
	Emmons lake	H. P. McElroy	" 12	80,000
Lapeer	Otter lake	J. C. Mason	" 12	200,000
	Powderhorn lake			
	Parke lake			
	Dipper lake	Will J. Till	" 12	200,000
	Bronson lake	I. M. Fisher	" 12	200,000
Lenawee	Devil's lake	J. B. Flanders	" 16	600,000
	Sand lake	Geo. A. Keil	" 16	200,000
Livingston	Pickerel lake	J. J. Van Lewen	" 11	160,000
	Island lake	Effie Josselyn	" 11	160,000
Montcalm	Baldwin lake	T. I. Phelps	" 11	240,000
	Burgess lake			
Oakland	Pine lake	Morgan A. Rundell	" 13	400,000
	Island lake	G. S. Shattuck	" 13	400,000
	McCain lake	Morgan Gulick	" 12	200,000
Otsego	Calkins lake	O. H. Carpenter	" 16	240,000
	Cranberry lake	Jno. D. Foster	" 16	240,000

Wall-eyed Pike Plants, 1896.—CONCLUDED.

County.	Name of waters.	Depositor.	Date.	Number.
St. Joseph	Ayers lake	H. Ayers	May 13	160,000
	Fisher lake	Francis B. Carr	" 13	160,000
Van Buren	Sherman lake	Michael Gales	" 11	240,000
Washtenaw	South lake	Arl Guerin	" 11	120,000
Wayne	Detroit river	Michigan Fish Commission	" 16	4,800,000
Total				13,720,000

Black Spotted Trout Plants, 1895.

County and name of waters.	Township.	Depositor.	Date.	Number.
Newaygo:				
South branch of Pere Marquette river	Several	Mich. Fish Com.	August 14	8,000

Small Mouth Black Bass Plants, 1895.

County and name of waters.	Township.	Depositor.	Date.	Number.
Cheboygan:				
Douglas lake	Munroe	John Johnson	June 15	16,000
Genesee:				
Barnum's lake	Fenton	Levi Barnum	May 14	3,000
Copeneconie lake	Holly, Fenton and others	" "	" 14	3,000
Kalamazoo:				
Asylum lake	Kalamazoo	Herman Ostrander	" 18	6,000
Gull lake	Ross, Barry & Richland	J. T. Upjohn	" 18	9,000
White lake	Kalamazoo	C. E. Foote	" 18	9,000
Burgess lake	Eureka	W. R. Holden	" 22	5,000
Lapeer:				
Otter lake	Marathon	Charles Hatherly	" 16	3,000
Barnes lake	Richland	John L. Preston	" 16	9,000
Montcalm:				
Colby lake	Evergreen	H. L. Bailey	" 14	3,000
Muskegon:				
Duck lake	Fruitland	John R. Austin	" 25	6,000
Oakland:				
Davis lake	Springfield	F. G. Ely	" 14	3,000
Rice lake	Holly	J. H. Porter	" 14	3,000
Orchard lake	Forest, Campbell	W. Bloomfield	" 14	5,000
Mace Day lake	Waterford	A. W. Blain	" 14	5,000
Lotus lake				
Big lake	Springfield	F. G. Ely	" 14	3,000
Total				91,000

Small Mouth Black Bass Plants, 1896.

County and name of waters.	Township.	Depositor.	Date.	Number.
Antrim:				
Intermediate lake	Central Lake	John C. Mathews	May 23	12,000
Lake of the Woods	Custer	C. L. Bailey	" 13	4,000
Cass:				
Baron lake	Howard	Charles E. Smith	June 12	10,000
Emmet:				
Crooked lake	Littlefield	Charles Bullock	May 18	10,000
Pickerel lake	"	O. C. Cope	" 18	8,000
Jackson:				
Clear lake	Waterloo	Orville Gorton	" 21	4,000
Round lake	Liberty	Chas. J. Van Schoick	June 10	8,000
Kalamazoo:				
Barton lake	Schoolcraft	Henry I. Allen	May 26	6,000
Sugar Loaf lake	Schoolcraft and Portage	W. C. Kohl	" 26	6,000
West lake	Kalamazoo	C. E. Foote	" 12	6,000
White's lake	"	" "	" 12	6,000
Lyon's lake	"	" "	" 12	6,000
Kalkaska:				
Starvation lake	Glade	C. L. Bailey	" 13	4,000
Twin lakes	Glade & Cold Springs	" "	" 13	4,000
Crooked lake	Glade	" "	" 13	4,000
Indian or Squaw lake	"	" "	" 13	4,000
Kent:				
Campau lake	Caledonia	Lew D. Stark	June 14	1,000
Reed's lake	Grand Rapids	Consolidated Railway Co.	" 30	300
" "	" "	G. S. Johnson	May 26	3,000
Lapeer:				
Otter lake Powderhorn lake Park lake	Marathon	J. C. Mason	" 21	12,000
McKeon lake	Oregon	Will J. Till	" 21	6,000
Hemingway lake	Marathon	" "	" 21	6,000
Leelanau:				
Manitou lake	Manitou Island	Samuel H. Row	" 18	6,000
Lenawee:				
Devil's lake	Woodstock	Hope Welch	June 10	6,000
Sand lake	Franklin and Bainbridge	J. J. Putnam & Sons	" 10	6,000
Livingston:				
Zuke lake	Hamburg	W. H. Bennett	" 15	4,500
Mecosta:				
Clear lake	Colfax	A. S. Hobart	" 15	4,000
Newaygo:				
Pickerel lake Kimball lake Bigand lake Little Marl lake	Brooks and Garfield	Geo. E. Taylor	May 23	8,000
Oakland:				
Mace Day lake	Waterford	Geo. S. Hammond	June 3	6,000
St. Clair:				
Mill creek	Clyde & Kenockee	A. R. Avery	May 15	10,000
Black river	Clyde, Grant & Worth	" "	" 15	10,000
St. Joseph:				
Fisher lake	Fabius	H. H. Whipple	" 26	5,000
Kaiser lake	"	Ed. M. Shafer	" 26	5,000
Corey lake	"	J. H. Hahn	" 26	6,000
Long lake	"	H. H. Whipple	" 26	6,000
Thompson lake	Sherman	E. V. Hohndue	" 12	4,000

Small Mouth Black Bass Plants, 1896—CONCLUDED.

County and name of waters.	Township.	Depositor.	Date.	Number.
Van Buren:				
Lake of the Woods	Decatur	Frank C. Stapleton	June 12	6,000
Washtenaw:				
Whitmore lake	Northport	W. H. Bennett	" 22	6,000
Wexford:				
Big Clam lake	Cadillac	H. F. Hodges	May 18	6,000
Little Clam lake				
Wayne:				
Detroit river	Detroit	Mich. Fish Com.	July 6	4,000
Total				238,800

Large Mouth Bass Plants, 1895.

County and name of waters.	Township.	Depositor.	Date.	Number.
Barry:				
Wall lake	Hope	W. D. Hayes	May 20	6,000
Danch lake	Rutland	W. J. Michael	" 20	6,000
Leach lake	Carlton	L. A. Crowell	" 20	4,000
Middle lake	"	" "	" 20	6,000
Carter lake	Irving	J. H. Neiss	" 20	6,000
Long lake	Rutland	W. D. Bennett	" 20	6,000
Cass:				
Hutchins lake	Newburg	Albert Bogert	" 27	5,000
Pleasant lake	Ontwa	Eugene D. Smith	" 27	5,000
Miller lake	Marcellus	C. S. Jones	" 27	5,000
Big Fish lake	"	" "	" 27	5,000
Saddle Bag lake				
Fish lake	"	W. L. Arnold	" 27	5,000
Fike lake	"	Robert J. Brown	" 27	5,000
Goff lake	"	E. P. McKenzie	" 27	5,000
Jackson:				
Fox lake	Hanover	W. H. Sanderson	" 24	6,000
Bibbins lake	"	T. J. Strait	" 24	6,000
Vandercook	Summit	George E. Beebe	" 24	4,000
Brown's lake				
Pleasant lake	"	" "	" 24	6,000
Kalamazoo:				
Sugar Loaf lake	Schoolcraft	Chas. W. D. Allen	" 27	5,000
Kent:				
Woodbeck lake	Oakfield	W. R. Holden	" 22	6,000
Banks lake				
Horse Shoe lake				
Half Mile lake				
County Line lake	Oakfield and Eureka	" "	" 22	5,000
Bass lake	Spencer	" "	" 22	5,000
Mecosta:				
Miller lake	Colfax	A. W. Eldridge	" 21	5,000
Muskegon:				
Wolf lake	Egleston	E. D. Magoon	" 25	6,000
Montcalm:				
Whitefish lake	Pierson	S. C. Scott	" 21	5,000
Rock lake	Richland	Edgar S. Wagar	" 21	6,000
Whitefish lake	Pierson	S. C. Scott	" 21	6,000
Turk lake	Montcalm	W. R. Holden	" 22	5,000
Total				145,000

Large Mouth Bass Plants, 1896.

County and name of waters.	Township.	Depositor.	Date.	Number.
Kalkaska:				
Lake Twenty-eight	Orange	Peter Elzcorn	May 13	6,000
Kent:				
Reed's lake	Grand Rapids	G. S. Johnson	" 26	5,000
Campau lake	Caledonia	Lew D. Stark	June 4	2,000
Van Buren:				
Wolf lake	Almena	James Buckhout	May 12	6,000
Total				19,000

Gold Fish Distributions, 1895.

Name.	Place.	Date.	Number.
F. J. Newman	Bay City	October 19	12
F. Briggs	Battle Creek	" 19	12
Frank Cornell	Belding	August 29	10
C. K. Hoyt	Hudsonville	September 16	15
A. S. Hill	Kalamazoo	" 16	4
H. W. Davis	Grandville	" 16	5
A. Chilver	Grand Rapids	August 23	15
E. C. Brown	Saginaw	October 19	25
Lincoln H. Titus	Paw Paw	August 26	10
Grant W. Gordon	Dearborn	October 24	6
Miss Mae Clark	Detroit	" 23	6
Mrs. Wm. Connor	"	" 23	6
Chas. T. Duffie	"	" 20	25
C. A. Seely	"	" 3	5
H. W. Davis	Distrib'd in Gr'd Rapids		150
Total			306

Gold Fish Distributions, 1896.

Name.	Place.	Date.	Number.
W. J. Martin	Bay City	October 14	12
E. P. Oviatt	Lansing	“ 13	12
J. M. Lee	Grand Rapids	“ 20	2
Mr. ——— Miller	“ “	“ 20	2
Mr. ——— Westover	“ “	“ 20	2
Mr. ——— Orr	“ “	“ 20	10
Wesley Knight	“ “	“ 20	10
Mrs. ——— Utter	“ “	“ 20	2
Mr. ——— Inman	“ “	“ 20	2
Mr. ——— Brewster	“ “	“ 20	4
Soldiers' Home	“ “	“ 20	6
Mr. ——— Brown	“ “	“ 20	2
Mr. ——— Bates	“ “	“ 20	2
State Fair	“ “	“ 20	2
Jas. Thiel	Mill Creek	“ 20	4
H. W. Davis	Grand Rapids	“ 12	60
S. Alexander	Birmingham	“ 13	20
Mr. ——— Brown	Saginaw	“ 12	25
Lincoln H. Titus	Paw Paw	“ 16	12
Alex. Baker	Ypsilanti	“ 13	10
Harriet W. Larkins	Detroit	“ 20	10
Myra Jones	“	“ 20	10
George T. Greene	“	“ 20	15
Irene C. Farquhar	“	“ 20	15
J. L. Roark	“	“ 15	10
Miss J. Anderson	“	“ 8	5
Mrs. W. B. Pope	“	“ 3	5
Detroit Normal School	“	“ 18	12
J. W. Hopkins	“	September 30	6
Winifred F. Smith	“	“ 18	12
Wm. H. Baxter	“	“ 30	6
Public schools by Louise Miller	“	October 20	150
Mrs. Alice E. Travers		May 14	6
F. G. Jaenischen		“ 14	6
Brice B. Hatter		“ 14	6
Parke, Davis & Co.		“ 14	12
Total			487

Carp Distributions, 1895.

County and name of waters.	Township.	Depositor.	Date.	Number.
Antrim:				
Private pond	Mancelona	W. H. Kettle	August 24	40
" "	"	E. A. Kemp	" 24	40
" "	"	" "	" 24	40
Barry:				
Mud lake	Barry	Addison Pennock	" 21	40
Gillispie lake	"	" "	" 21	40
Bullhead lake	Carlton	J. W. Foster	" 21	20
Irving Mill pond	Irving	Luther S. Mills	" 21	20
Benzie:				
Gary lake	Almira	M. W. Courson	" 24	40
Kenyon lake	"	" "	" 24	40
Calhoun:				
Aquarium	Battle Creek	F. Briggs	" 24	12
Cass:				
Private pond	Newburg	Fred Jones	" 19	100
Clare:				
Green's lake	Hatton	John Quinne	" 30	40
Chippewa:				
Trout brook	Rudgard	R. G. Trimble	October 15	25
Clinton:				
Private pond	Ovid	James Valentine	August 29	40
Dickinson:				
East lake	Breen	S. H. Bridges	October 16	19
Lake on Secs. 10, 42 and 27	"	" "	" 16	19
Emmet:				
Cecil lake	Carp Lake	W. E. Robinson	" 19	20
Genesee:				
Atlas Mill pond	Atlas	P. W. Gale	" 19	20
Private pond	Genesee	J. P. Murray	" 19	20
Long's lake	Davison	L. J. Wicker	September 4	40
Potter lake	Genesee and Lapeer	" "	" 4	40
Byron and Pine lakes	Fenton	Frank J. Sadler	" 3	40
Gogebic:				
Crozier's lake	Watersmeet	L. L. Wright	October 16	40
Mud lake	Marenisco	" "	" 16	19
Hillsdale:				
Private pond	Hillsdale	Marion G. Mosher	August 20	50
Cambria Mill pond	Cambria	Geo. H. Busch	" 20	50
Cub lake	"	Frank Weston	" 20	50
St. Joseph river	Jefferson	Clayton Powell	" 20	75
Houghton:				
Seneca lake	Calumet	John Duncan	October 15	19
Mud lake	South Lake Linden	Charles Smith	" 15	19
" "	Duncan	G. W. Shane	" 16	19
Iron:				
Private lake	Atkinson	Paul Schultz		19
Private pond	Crystal Falls	A. Lustfield		19
Isabella:				
Obrien lake	Lincoln	Birton I. Gee	August 27	80
Town Frye lake	Gilmore	N. J. Phillips	" 30	40
Jackson:				
Liberty Mill pond	Liberty	R. C. Cary	" 20	50
Kent:				
Private pond	Grandville	Vonderodde George	" 21	40
" "	Hudsonville	C. K. Hoyt	" 21	190
" "	Grand Rapids	Chas. H. Chick	" 23	40
Flat river	Vergennes	E. J. Mosher	" 29	40

Carp Distributions, 1895.—CONCLUDED.

County and name of waters.	Township.	Depositor.	Date.	Number.
Lapeer:				
Perch pond	Attica	J. R. Bellow	September 3	40
Lenawee:				
River Raisin	Adrian	C. E. Brush	August 20	50
“ “	“	“ “	“ 20	100
Livingston:				
Dollar lake	Brighton	J. J. Van Lewen	September 2	40
Pickerel lake	“	“ “	“ 2	40
Marquette:				
Bancroft lake	Ishpeming	Geo. A. Newett	October 15	19
Mecosta:				
Private lake	Morton	Frank Cole	August 27	40
Pine lake	Wheatland	A. L. Hawk	“ 27	4
Private pond	“	C. H. Roberts	“ 27	40
Guy and Mud lakes	“	A. L. Hawk	“ 27	40
Pine lake	Chippewa	James A. Roop	“ 27	80
Montmorency:				
Mud lake	Vienna	Thomas E. Double	October 19	20
Muskegon:				
Christie lake	Whitehall	Christopher Kelett	August 27	40
Newaygo:				
Whipple lake	Barton	Urias Gardner	October 14	19
Orton lake	Brooks	W. H. Kritzer	August 27	40
Butterworth lake	Brown	E. O. Shaw	“ 27	150
Private pond	Otia	L. M. Barnes	“ 27	40
“ “	Fremont	George Gould	“ 27	40
Oakland:				
Martin lake	Holly	James Martin	October 19	20
Cedar lake	Brandon	Alonzo Flagler	September 3	40
Causeway lake	“	R. Kent	“ 3	40
Private pond	Ortonville	John D. McIntire	“ 3	40
Cedar lake	Brandon	Peter L. McIntire	“ 3	40
Round lake	“	Wildor Clark	“ 3	40
Private pond	Groveland	A. H. Austin	“ 3	40
sceola:				
Woolworth lake	Burdell	Theodore Rogers	August 24	40
Otsego:				
Stream on Sec. 15	31 N., 2 W.	A. A. Crane	October 19	20
Ottawa:				
Private pond	Hudsonville	G. L. Guild	August 21	40
Schoolcraft:				
Mud lake	Germfask	Edward Menere	October 15	40
Tuscola:				
Private pond	Arbela	H. A. Daniels	“ 19	20
Dollar lake	Millington	Robert H. Murray	September 3	40
Van Buren:				
Briggs pond	Paw Paw	C. Engle	August 21	20
Willard pond	“ “	“ “	“ 21	20
North lake	Pine Grove & Almena	Wm. C Gibson	“ 21	40
Veley's pond	Pine Grove	Charles Veley	“ 21	40
Sherman's lake	Paw Paw	C. Engle	“ 21	20
Brown lake	Keeler	Samuel Scott	“ 22	80
Private pond	Decatur	Thomas Brandhurst	September 18	8
Wexford:				
Johnson's pond	South Branch	George W. Johnson	August 24	40
Total				3,225

Carp Plants, 1896.

County and name of waters.	Township.	Depositor.	Date.	Number.
Alpena:				
Misery bay	Alpena	W. E. Rogers	August 14	80
Baraga:				
Lake Cosgrove	Baraga	N. S. Pennock	" 15	60
Plain lake	"	" "	" 15	60
Three lakes on Section 14	Spur	George McDonald	" 15	40
Barry:				
Long lake	Hope	Dugal Campbell	" 6	100
Sawbaw lake	Rutland	D. A. Holbrook	" 6	300
Calhoun:				
Goose lake	Penfield	Edward J. Smith	" 8	400
Crawford:				
Pickerel lake	27 N., 4 W.	H. V. Howe	" 14	110
Eaton:				
Private pond	Charlotte	James Murray	" 6	100
Genesee:				
Thread pond	Barton	Abram Peer	" 8	100
Gogebic:				
Sunday lake	Wakefield	L. L. Wright	" 17	40
Crozier lake	Watersmeet	" "	" 17	120
Grand Traverse:				
Root lake	Whitewater	L. L. Lydell	" 11	60
Houghton:				
Groomer lake and stream	47 N., 36 W.	Geo. H. Houser	" 16	40
Ionia:				
Mud lake	Berlin	Ralph Crane	" 6	80
Iron:				
Private pond	Crystal Falls	A. Lustfield	" 17	75
Lake Tissetta	Mastodon	Fred Velquette	" 17	75
Kalkaska:				
Rainbow lake	Coldspring	Wm. Thompson	" 11	80
Fisher's pond	Orange	Peter Etzcorn	" 11	80
Private pond	Boardman	Albert Sage	" 11	50
Kent:				
Hall's lake	Byron	George D. Hall		120
Bailey pond	Paris	S. S. Bailey		80
Private pond	"	" "		80
Lake:				
Wolf lake	Webber	Harley Bartlett	August 11	220
Lapeer:				
Skym's pond	North Branch	Wm. Skym	" 8	40
Mackinac:				
Round lake	St. Ignace	James Stevenson	" 14	60
Gallagher lake	"	" "	" 14	60
Manistee:				
Fox lake	Chandler	Neil Gallagher	" 11	50
Gallice lake	Gallice	" "	" 11	75
Barney lake	Pine	" "	" 11	50
Fond lake	Chandler	" "	" 11	75
Green's lake	Gallice	" "	" 11	50

Carp Plants, 1896.—CONCLUDED.

County and name of waters.	Township.	Depositor.	Date.	Number.
Mason:				
Lincoln lake	Hamlin and Pere Marquette	F. W. Graham	August 10	80
Mecosta:				
Wolcott pond	Big Rapids	L. E. Wolcott	" 10	40
Grass lake	Chippewa	James M. Roop	" 10	80
Montcalm:				
Steffenson's pond	Montcalm	Andrew Steffenson	" 6	50
Muskegon:				
Loveless lake	Cedar Creek	Louis Roupricht	" 7	100
Crystal lake	Whitehall	Christopher Klett	" 7	100
Newaygo:				
Whipple lake	Barton	Urias Gardner	" 7	100
Oakland:				
Long lake	Orion	Edward Miller	" 8	300
Oceana:				
Round lake	Golden	Harry M. Beals	" 6	100
Ontonagon:				
Private pond	Interior	Leonard Nelson	" 17	65
Otsego:				
Lake 15	Dover	John Goston	" 14	80
Sanilac:				
Private pond	Austin	Harrison J. Rathbun	" 11	40
Decker's pond	Lexington	George H. Decker	" 11	40
Schoolcraft:				
Mud lake	Germfask	Edward Menere	" 15	40
Shiawassee:				
Moon lake	Woodhull	Mil Pulver	" 8	400
Tuscola:				
Cass river	Vassar and others	M. D. Brainard	" 11	80
Washtenaw:				
River Raisin	Manchester	B. W. Amsden	" 6	120
Wayne:				
Private pond	Plymouth	D. W. Packard	" 7	160
Total				4,960

TEMPERATURE OF WATER.

DETROIT STATION.

Temperature of water during whitefish hatching season, from November 12, 1894, to April 27, 1895.

1894.		
Nov.	12-18	43°
	19-21	40
	22	39
	23	42
	24	43
	25	42
	26-27	45
	28	40
	29	39
	30	38
Dec.	1	38
	2	35
	3	40
	4	38
	5-6	37
	7-8	38
	9	40
	10-11	38
	12-14	40
	15-16	39
	17	42
	18-19	40
	20-23	39
	24-26	38
	27	37
	28-31	35
1895.		
Jan.	1	36
	2-3	35
	4	36
	5-6	35
	7-9	34
	10-15	33½

1895.		
Jan.	16-25	34°
	26	33
	27	33½
	28-31	33
Feb.	1-20	33
	21	35
	22-23	34
	24	33½
	25-28	34
Mar.	1	34
	2-3	33½
	4-5	33
	6-9	34
	10-18	33
	19	33½
	20-22	34
	23-24	34½
	25-29	35
	30-31	34
April	1-5	34
	6	35
	7-8	34½
	9-11	38
	12	39
	13	38
	14	38½
	15	39
	16	40
	17	39½
	18	40
	19	41
	20-27	43

Temperature of water during whitefish hatching season, from November 1, 1895, to April 22, 1896.

1895.		
Nov.	1	45°
	2-5	44
	6	44½
	7	46
	8-10	47
	11	46
	12-13	45
	14-19	44
	20	43
	21-23	42
	24-25	40
	26	43
	27	38
	28	37
	29	38
	30	39

1895.		
Dec.	1-3	37°
	4-5	36
	6-9	35
	10	34
	11-12	35
	13-15	34
	16-17	35
	18	36
	19	37
	20-22	35
	23	34½
	24-26	35
	27-28	34
	29-31	35
1896.		
Jan.	1-7	34
	8-9	33

DETROIT STATION.—*Continued.*

1896.		
Jan.	10	33½°
	11-18	33
	19	33½
	20	33
	21-31	34
Feb.	1-2	34
	3-5	33
	6-26	32
	27-28	33
	29	32
Mar.	1-3	32
	4	33
	5	32
	6-7	33
	8-13	32
	14-15	33
	16-20	32
	21-28	33
1896.		
Mar.	29-30	34°
	31	36
April	1	33
	2-4	32
	5	33
	6-8	34
	9-10	36
	11	38
	12	40
	13	42
	14-16	46
	17	48
	18	50
	19	52
	20	51
	21	52
	22	51

SAULT STE. MARIE STATION.

Temperature of water during trout and whitefish hatching season, from October 15 1894, to May 17, 1895.

1894.		
Oct.	15-31	50°
Nov.	1-2	49
	3-5	48
	6	47
	7-8	46
	9	45
	10	44
	11-14	43
	15-17	42
	18	41
	19	40
	20-21	38
	22	39
	23-25	38
	26-30	37
Dec.	1-4	37
	5-22	38
	23-24	37
	25	36
	26-31	35
1895.		
Jan.	1-2	35°
	3-31	34
Feb.	1-28	34
Mar.	1-31	34
April	1-15	34
	16	34½
	17	35
	18-20	36
	21-26	35
	27	36
	28-29	37
	30	38
May	1	38
	2	39
	3-10	40
	11-15	41
	16-17	42

Temperature of water during trout and whitefish hatching season, from October 1, 1895, to May 18, 1896.

1895.		
Oct.	1-4	50°
	5	51
	6	50
	7-10	51
	11	50
	12-13	51
	14-17	47
	18-21	45
	22	46
	23	47
	24	48
	25-28	45
	29	44
	30-31	43
Nov.	1	43
	2-5	44
	6	46
	7-8	45
	9	43
1895.		
Nov.	10-11	42°
	13	43
	14-15	44
	16-19	42
	20	39
	21	37
	22-23	38
	24-25	37
	26	36
	27	35
	28	36
	29	38
	30	36
Dec.	1	36
	2-6	35
	7	36
	9-14	34
	15-16	35
	17-20	36

SAULT STE. MARIE STATION.—*Concluded.*

1895.		
Dec.	21-22	37°
	23	36
	24-25	37
	26	36
	27-30	35
	31	33
1896.		
Jan.	1-20	33
	21	32½
	22-31	33
Feb.	1-15	33
	16-21	32½
	22-29	33
Mar.	1-31	33
April	1-12	33
	13-14	33½
	15-17	34
	18	34½

1896.		
April	19	35°
	20-21	36
	22-23	37
	24	38
	25	39
	26-27	40
	28-29	39
	30	40
May	1	40
	2	41
	3-5	42
	6-8	43
	9-12	44
	13	47
	14-15	45
	16	44
	17	45
	18	44½

PARIS STATION.

Temperature of water during trout hatching season from September 17, 1894, to July 1, 1895.

1894.		
Sept.	15	51°
	16	50
	17	48
	18	46
	19	44
	20	46
	21	48
	22	50
	23	47
	24	46
	25	44
	26	45
	27	47
	28	46
	29	46
	30	48
Oct.	1	44
	2-5	46
	6	44
	7-8	45
	9-11	43
	12	44
	13	45
	14	44
	15	40
	16-17	45
	18	43
	19-20	46
	21-22	48
	23	46
	24	45
	25	43
	26	47
	27	46
	28-29	45
	30	46
	31	45
Nov.	1-3	46
	4-5	45
	6	42
	7-8	43
	9	42
	10	41

1894.		
Nov.	11-13	40°
	14-17	42
	18	41
	20	38
	21	43
	22-23	42
	24	44
	25-26	42
	27	41
	28-30	40
Dec.	1-3	42
	4	39
	5-6	42
	7	43
	8	45
	9-10	42
	11-12	44
	13	43
	14-15	42
	16	45
	17	42
	18-20	40
	21	44
	22	40
	23	41
	24	42
	25	40
	26-27	38
	28	36
	29-31	38
1895.		
Jan.	1-2	38
	3	39
	4-5	38
	6	40
	7	42
	8	38
	9	37
	10	39
	11	40
	12	39
	13-15	42
	16-17	39
	18	38

PARIS STATION.—*Concluded.*

1895.		
Jan.	19	40°
	20	44
	21	40
	22–23	38
	24	36
	25	40
	26	39
	27–29	38
	30–31	36
Feb.	1	38
	2	34
	3–4	37
	5	35
	6–9	36
	10	37
	11–14	38
	15	36
	16	37
	17	38
	18	39
	19	37
	20	38
	21	40
	22	36
	23	37
	24	40
	25	38
	26	40
	27	43
	28	40
Mar.	1	40
	2–4	36
	5–6	37
	7	39
	8	40
	9	38
	10	40
	11	35
	12	37
	13	40
	14	35
	15	36
	16	37
	17–18	38
	19	40
	20-22	38
	23	39
	24-31	38
Apr.	1-3	38
	4	39
	5	40
	6	41
	7-8	42
	9	43
	10	40
1895.		
Apr.	11-12	42°
	13	43
	14-16	44
	17	43
	18	42
	19	43
	20-21	44
	22	46
	23	45
	24	44
	25	43
	26	44
	27-28	45
	29-30	46
May	1	46
	2-3	48
	4-5	47
	7-11	46
	12	40
	13	38
	14-16	40
	17	42
	18	44
	19	42
	20	40
	21	42
	22	43
	23	44
	24	45
	25	44
	26	45
	27	46
	28	45
	29	48
	30	47
	31	47
June	1	45
	2-4	46
	5-8	48
	9	47
	10-12	45
	13-14	47
	15-16	49
	17-18	50
	19	51
	20-21	50
	22-23	52
	24	49
	25	48
	26-27	49
	28	48
	29	47
	30	48
July	1	49

PARIS STATION.

Temperature of water during trout hatching season from September 15, 1895, to July 1, 1896.

1895.	
Sept. 15-17	50°
18-22	52
23	50
24-26	49
27-30	48
Oct. 1-2	45
3	44
4-5	46
6-7	49
8	45
9-10	44
11	48
12	46
13	45
14	48
15	45
16	48
17	47
18	48
19	47
20	40
21-22	42
23	43
24	46
25	47
26	46
27-30	42
31	43
Nov. 1-2	42
3	46
4	48
5	45
6-7	48
8	46
9	44
10	40
11-12	42
13	43
14-15	44
16-18	45
19	43
20-21	40
22	42
23	41
24-25	40
26-27	42
28	43
29	44
30	40
Dec. 1-2	40
3	39
4-6	40
7	42
8-9	38
10-12	40
13	37
14	38
15	39
16	38
17	41
18-19	42
20	41
1895.	
Dec. 21	42°
22	43
23	44
24	43
25	41
26	42
27	41
28	42
29	41
30-31	40
1896.	
Jan. 1	38
2	40
3	39
4-5	34
6	39
7-8	40
9-11	43
12	40
13	39
14	41
15	40
16-18	41
19	42
20-21	44
22	39
23	40
24-25	44
26	42
27	40
28	42
29	43
30	44
31	43
Feb. 1	43
2	42
3	40
4	42
5	41
6	40
7	41
8-10	40
11	37
12	36
13-14	38
15	40
16	36
17	35
18	36
19	38
20	36
21-22	38
23-24	40
25	37
26	40
27-28	41
29	38
Mar. 1-5	38
6	40
7-8	39
9-10	40
11	38
12	37

PARIS STATION.—*Concluded.*

1896.		
Mar.	13	35°
	14	36
	15	37
	16	38
	17	40
	18	41
	19	42
	20	37
	21-22	38
	23	36
	24	37
	25	40
	26-27	39
	28-29	40
	30	41
	31	40
Apr.	1	41
	2-4	38
	5	39
	6-9	40
	10	41
	11	43
	12	44
	13-15	45
	16-17	48
	18	49
	19	48
	20-21	46
	22	43
	23-24	42
	25	44
	26	46
	27	47
	28	46
	29-30	48
May	1	47
	2-5	48

1896.		
May	6	47°
	7-10	48
	11	49
	12-14	48
	15-16	47
	17-20	48
	21	49
	22	50
	23	52
	24	50
	25	52
	26	50
	27	48
	28	50
	29-31	48
June	1	46
	2	47
	3	49
	4	50
	5	51
	6-7	52
	8	53
	9	51
	10	49
	11	48
	12	49
	13-14	48
	15	49
	16-18	48
	19	49
	20-21	50
	22-23	49
	24	48
	25-26	50
	27-29	49
	30	47

CHARLEVOIX RELIEF STATION.

Temperature of water during whitefish hatching season from the time the eyed eggs were put in the jars, February 17 to April 25, 1895.

1895.			1895.		
Feb.	17-18	33°	Mar.	28-31	34°
	19-24	33½	Apr.	1-2	35
	25-28	33		3-4	34
Mar.	1-2	32½		5	35
	3-12	33		6-14	36
	13-14	34		15-18	38
	15-22	33		19-21	39
	23-25	34		22-25	40
	26-27	34½			

CHARLEVOIX RELIEF STATION.

Temperature of water during whitefish hatching season from November 15, 1895, to April 28, 1896.

1895.			1896.		
Nov.	15-17	44°	Jan.	13-14	32°
	18-22	43		15-22	33
	23-24	42		23-31	34
	25-26	43	Feb.	1-24	33
	27	42		24-26	34
	28	41½		27-29	33
	29	41	Mar.	1-2	33
	30	40		3-5	34
Dec.	1-3	40		6-12	33
	4	38½		13-15	34
	5-7	38		16-18	33½
	8-9	37		19-22	34
	10-12	38		23-31	--
	13	36½	Apr.	1-2	35½
	14-17	36		3-8	36
	18-19	37		9	35½
	20	38		10	34½
	21	37		10	36½
	22-24	36		12-15	38
	25-26	35½		16-17	39
	27	35		18-20	38
	28-30	36		21-22	39
	31	35		23	40
1896.					
Jan.	1-3	34		24	39
	4-9	33		25-26	40
	10-12	32½		27-28	42

INSURANCE.

On Detroit hatchery, building	$2,000 00
On automatic hatching jars, Detroit	1,600 00
On Paris hatchery, building	2,500 00
On troughs and equipment	650 00
On car house at Paris	125 00
On overseers' dwelling at Paris	1,000 00
On old hatchery building, Paris	500 00
On tanks, boxes, etc.	200 00
On fixtures and tools	100 00
On employés' dwelling, Paris	400 00
On barn at Paris	100 00
On wagons and harness at Paris	50 00
On Sault Ste. Marie hatchery building	4,000 00
On fixtures and equipment	500 00
Total	$13,725 00

SUMMARY OF INVENTORY AUGUST 1, 1896.

Detroit station	$15,839 92
Paris station	19,622 65
Sault Ste. Marie station	6,191 37
Glenwood station	245 71
Charlevoix station	955 35
Car and equipment	4,279 39
Cascade station	235 00
Secretary's office	586 97
Total	$47,956 36

FINANCIAL STATEMENT.

1894. Oct. 1	Overdraft		$1,434 48
	From State Treasurer during quarter ending December 31	$12,225 00	
	From other sources	2,840 24	
	Vouchers paid during quarter		13,627 87
Dec. 31	Balance		2 89
		$15,065 24	$15,065 24
1895. Jan. 1	Cash on hand	$2 89	
	From State Treasurer during quarter ending March 31	9,450 00	
	From other sources	24 57	
	Vouchers paid during quarter		$5,640 12
Mar. 31	Balance		3,837 34
		$9,477 46	$9,477 46
April 1	Cash on hand	$3,837 34	
	From State Treasurer during quarter ending June 30	2,000 00	
	Vouchers paid during quarter		$5,531 78
June 30	Balance		305 56
		$5,837 34	$5,837 34
July 1	Cash on hand	$305 56	
	From State Treasurer during quarter ending September 30	11,750 00	
	Vouchers paid during quarter		$8,715 79
Sept. 30	Balance		3,339 77
		$12,055 56	$12,055 56
Oct. 1	Cash on hand	$3,339 77	
	From State Treasurer during quarter ending December 31	6,875 00	
	From other sources	3,250 22	
	Vouchers paid during quarter		$13,027 84
Dec. 31	Balance		437 15
		$13,464 99	$13,464 99
1896. Jan. 1	Cash on hand	$437 15	
	From State Treasurer during quarter ending March 31	11,875 00	
	Vouchers paid during quarter		$7,787 73
Mar. 31	Balance		4,524 42
		$12,312 15	$12,312 15
April 1	Cash on hand	$4,524 42	
	From State Treasurer during quarter ending June 30	6,875 00	
	Vouchers paid during quarter		$6,956 80
June 30	Balance		4,442 62
		$11,399 42	$11,399 42
July 1	Cash on hand	$4,442 62	
	From State Treasurer during quarter ending September 30	6,875 00	
	Vouchers paid during quarter		$6,827 99
Sept. 30	Balance		4,489 63
		$11,317 62	$11,317 62

THE FOOD SUPPLY OF THE FISH IN THE GREAT LAKES.

BY PROF. H. B. WARD.

[From the Nebraska Literary Magazine, Lincoln, Neb., November, 1895.]

When the early settlers made their homes along the shores of the Great Lakes, the waters of these inland seas teemed with fish. A cheap and apparently inexhaustible supply of food lay within easy reach, and they drew from it unstinted, nor was it strange that, with the increasing population and ever-widening means of communication, delicacies so tempting as the whitefish and lake trout were eagerly sought after in the markets of the neighboring cities, and that the ingenuity of generations of fishing folk was taxed to invent means of securing the fish—until finally, in the face of a growing demand and of improved apparatus for trapping the fish, natural methods of increase did not keep pace with the draft on the supply, and lake fish began to grow scarcer year by year. Artificial propagation had been tried in Europe, had proved a successful means of restocking depleted streams and ponds, and the newly founded fish boards of various states, charged in at least one case, Michigan, with the especial care of the whitefish, sought to perfect methods for hatching whitefish eggs. They were confident that therein lay the remedy for a great national calamity that seemed fast approaching—the loss of a food supply which, on the one hand, in its capture and distribution, gave employment to hundreds of men and vessels, and on the other furnished a cheap and agreeable supply of food to a large part of the central United States. But the methods which were so eminently successful in other instances have failed of final success in the Great Lakes. The annual catch of whitefish seems to be on the decline in spite of large sums spent by State and national fish commissions in hatching the fry and distributing them in the waters of the lakes. It has been a keen disappointment to all interested in fish culture that more immediate and pronounced results have not followed the extensive yearly plants of the fry; and some have attempted to explain the apparent failure on the ground that the present destructive methods of fishing effectually forbid any increase in the number of fish. They have, therefore, called for more stringent legislative regulations concerning methods of fishing, and for increased activity and artificial propagation. On the other hand it is evident that existing methods of fish culture may be open to criticism, and that the remedy as well as the fault must be sought here.

In an address before the World's Fishery Congress at Chicago in 1893, Professor J. E. Reighard says on this point:

"If we inquire into the facts concerning the sufficiency of the present methods of artificial propagation, we find that so far as concerns the whitefish there is no question as to the success of the earlier stages of the process. Several hundred million ova are taken annually and placed in the hatcheries, and of these usually from 80 to 90 per cent are hatched and placed in the waters of the Great Lakes—165,000,000 in Lake Erie alone in 1888.

"This is very nearly all that is known about these young whitefish. About their food habits we know only that in captivity they eat certain species of Crustacea. Whether in their natural habitat they eat other animals in addition to these Crustacea, or in preference to them, we do not know. It is uncertain at what age they begin to take food or how much they require. We do not know their natural enemies. We do not know whether they thrive best in running water or standing water, in shallow water or in deep water, whether at the surface or near the bottom. What changes of habitat or of food habits the fish undergo as they grow older is still a deeper mystery.

"Our problem is to place young whitefish in the Great Lakes under such conditions that as large a number as possible of them shall grow into adult fish. It is clear that one of these elements in this problem, namely, the whitefish, we know but little.

"What, then, do we know of the other elements of the problem, the Great Lakes themselves? Individual naturalists have made efforts from time to time to study one or another of the groups of animals living in the lakes. These efforts have been always circumscribed by the facilities at hand, by the time that could be devoted to the subject, by the small area examined, or by the small number of animals taken into account. Although much excellent work has resulted from these efforts, it remains true that there has been thus far no attempt to secure an accurate knowledge of all the conditions existing in any one locality, and no attempt to study exhaustively a single group of animals and plants of the lakes. We are still at the beginning so far as concerns a knowledge of life conditions in these lakes, the conditions with which we surround our young whitefish. If we could assume that the conditions are uniform over the whole area of the Great Lakes, then since the young whitefish are natives of these lakes, it might be a safe conclusion that they will find the conditions in one locality as well for them as in another. But there are no facts which support the view that the conditions are uniform over the lakes.

"We are thus in the position of bringing together under unknown conditions two things, both of unknown character, and we expect as a result to get a third thing—marketable whitefish. Should we not pursue our object more intelligently by first determining the characteristics of the materials with which we have to work?"

For ten years the Michigan Fish Commission had been carrying out a systematic investigation of the inland lakes of that State and had collected most valuable evidence on the biological conditions in these smaller bodies of water. The results of this survey, even as yet incomplete, have been immediate and invaluable, and it was a natural step when, under the advice of Professor Reighard, it was decided to extend operations to the Great Lakes themselves. In the summer of 1893 a scientific laboratory was maintained on Lake St. Clair, and, under the guidance of the director, Professor J. E. Reighard of the University of Michigan, a party of six specialists devoted two months to the study of the life in the lake. In 1894 Charlevoix, on the northeastern shore of Lake Michigan, was selected as a site for work, and owing to the absence of Professor Reighard in Europe, the writer was placed in charge.

Lake St. Clair has long been famous as the spawning ground for the whitefish; it is comparatively shallow, having a maximum depth of but a little more than six meters, and is of limited area. Both inflow and outflow are very large, and in fact the lake constitutes hardly more than a slight enlargement in the course of the stream connecting Lakes Huron and Erie.

In the waters of the Charlevoix region whitefish are caught the year round, and Lake Michigan has an area of more than 23,000 square miles and a maximum depth of 870 feet. It is estimated to contain at least one-tenth of all the fresh water of the globe. On the other hand the inflow and outflow are so inconsiderable in comparison that the volume may be said to be stable. Furthermore, the amount of shallow water is meagre, the area included between the shore and the ten-fathom line constituting hardly an appreciable amount on the chart of the lake; and yet this depth is more than two and one-half times the maximum of Lake St. Clair. The shallow area being thus limited, there is a relative scarcity of the larger plants which are found only in areas of limited depth; and the development of the strictly littoral forms is further hindered by the storms which subject the shore to constant change and prohibit on it any permanent plant growth.

It must also be remembered that light and temperature decrease rapidly with increase in depth while at the same time the pressure to which organisms are subjected increases with equal rapidity. Hence, the considerable depth of the major part of the lake affects very markedly the conditions for existence. In these respects Lake Michigan affords a strong contrast to the ordinary inland lake, while it is on the other hand a typical representative of the great inland seas. Similar conditions hardly exist elsewhere in the civilized world. It should be remembered that the work of European investigators has been carried on in lakes of comparatively limited area and depth, and that results characteristic of such conditions cannot, without further evidence, be extended to the larger bodies of water.

It must be noted that the question of food supply for the fish is peculiarly unlike the similar problems in agriculture. The food animals which come under our immediate attention are almost without exception herbivorous. The supply of food is drawn directly from the inorganic material in earth, air, and water, through the single intermediate step of the grasses, grains, and various forage plants. The chain of biological relations in this case is short and simple in its main features. Furthermore, constant and careful study by many workers in scientific institutions and on experimental fields has done much to explain the details of the process. The preparation and enrichment of the soil, the development of the seed, the growth of the plant, the dangers that threaten it, the diseases and pests that attack it, its protection and improvement, are all subjects of continued investigation. On the other hand, the pisciculturist has had no such aid, and, worse than that, often does not know even the immediate food of the fish or its amount and distribution, while concerning the more remote questions he has hardly thought to ask for their solution. In fresh water there are few large plants, in the Great Lakes a still scantier amount. Among all the fish there are none that depend on these plants for food supply; they are purely carnivorous.

In the light of the universal dependence of animal life upon plant life, one of the most fundamental questions for the fish culturist is the primitive food supply of the lakes in its character, amount, and distribution, since on this evidently depend the possibilities of fish culture, and with variations in it are connected necessarily variations in the number of fish. Unless the primitive food supply be abundant at the present time, all efforts to increase the number of fish will be only partially successful, and, unless the food of the fry is to be found in sufficient quantities in that locality when the fry are planted, the maximum number can never attain to the adult condition. The subject is too large for the limits of one paper or of a single series of investigations. Here I desire to present some results drawn from the work on Lake St. Clair and Lake Michigan with reference to the general question of the source of the food supply, its character, amount, and distribution. The more particular question with reference to the whitefish has been discussed elsewhere.

The source of food supply is not to be sought in the streams flowing into the lake. The amount brought in this way constitutes not only a very small part of the total volume, far too insignificant to be an important factor in the question, but it is furthermore chiefly inorganic matter in suspension or solution which is contributed from this source. The very limited development of bottom flora precludes the possibility of considering it the source of food supply, and the barren character of the littoral zone shows that from it is derived only inorganic matter by wave action. From the atmosphere comes in the rain much valuable material, but here exclusively inorganic. It is clear, then, that the primitive organic food material does not reach the Great Lakes from some source or other apart from them; it must be sought in the water itself.

If at any point in the clear, free water of the lake a net of finest miller's gauze be lowered to a depth of a few meters or more, and raised so as to strain the water and collect whatever may be present, it will be found on subsequent examination to contain numerous minute organisms, plant and animal, in varying quantity. It matters not whether the place of the experiment be near the shore or distant from it, in shallow or deep water, or whether the net be lowered only a short distance or to the bottom; there will always be obtained a certain quantity of life from the water, varying in amount with different circumstances. All the organisms obtained, both plant and animal, are characterized by their minute size, and are evidently unable by their own powers of locomotion to influence materially their position in the water. The environment to which they are subject is the result of external agencies and cannot be modified by their own efforts. They do not seek the bottom or the shore for rest, but remain always floating in the open water. All such forms together constitute what is called the *plankton*. Near the shore the plankton is corrupted by the addition of migrants from the littoral fauna and flora, and in proximity to the bottom some additions come to it from the bathybic (bottom-living) forms; but throughout by far the greater part of the water the plankton is found unmixed with other elements. Although present in small lakes and ponds it is more characteristic of larger bodies of water, both fresh and salt. In fresh water the fish alone invade its territory, and yet there are few fish that depend upon it directly for food. But the biological relations will be clearer after a consideration of some of the widely different forms of life included under the term plankton.

Four elements constitute the plankton of the Great Lakes, the unicellular plants and animals, or the Protophyta and Protozoa, the Rotifera, and the Crustacea. The number of species of each which are found in the plankton of the Great Lakes is limited, in fact not more than half as many as can be had from smaller bodies of water, but each species is present in an enormous number of individuals. Kellicott has calculated that of a single protophyte *(Stephanodiscus)* eight tons pass daily from Lake Erie into the Niagara river.

These forms together constitute the primitive food supply of the water, and the Protophyta are the fundamental element. They float in a nutritive fluid, the water of the lake which holds in solution inorganic substances obtained from the air, water, and shore, and brought down by various streams. In common with other green plants, they are able to manufacture out of this inorganic matter living material. Leuckart was the first to point out that since chemical action proceeds most rapidly where the proportion of surface to volume is the greatest, these organisms are peculiarly adapted to rapid growth. And since with them reproduction is clearly growth beyond the limits of the individual and consequent division into two organisms, under favorable conditions of light, temperature, and so forth, generation follows generation, with extraordinary rapidity, myriads are produced and are destroyed in every moment. These Protophyta of the plankton are then the actual elementary food supply, and all other forms of the plankton as well as all higher forms are in last analysis dependent upon them.

With them, however, may be included in the primitive food supply the other elements of the plankton. The Protozoa subsist in general on the Protophyta, the Rotifera are dependent upon both, and the Crustacea make way with whatever falls in their way. This last group usually predominates in the plankton, constituting in most cases by far the larger part of the entire volume. It is also the immediate source of fish food, serving directly as the food of the fry and rarely of the adult fish also, as in the case of the lake herring. Of the adult food fish the trout are piscivorous, subsisting on the herring and smaller forms, while the food of the various species of whitefish consists of bottom forms, such as *mollusks, insect larvæ, and crustaceans of medium size,* all of which are dependent upon the plankton for their food supply.

The fundamental position occupied by the plankton in the series of food relations in the Great Lakes renders it in the highest degree advisable that its quality, quantity, and distribution be accurately determined. The method employed in obtaining material for this determination is peculiar. In the case of ordinary collecting a net is towed behind the boat for an indefinite distance and only such part of the "catch" is utilized as may be convenient. Here the exact amount, and the volume of water from which it is taken are necessary factors in estimating the relative fertility of the water. The boat is brought to anchor, a net of peculiar construction is lowered to the bottom, and after a moment hauled vertically to the surface. The time consumed in the haul is recorded, as are also the depth, temperatures of air top and bottom, and if possible the character of the bottom, the condition of the sky and surface of the water, and the amount of current, if any, that exists at this point. At each point a number of hauls are made from varying depths, and the total amount of material obtained in each haul is preserved and bottled so carefully that the loss is very small. The error is always negative, however, and the amount obtained can be greater than is present only if foreign matter be included, and this is easily detected by the microscope. The material thus collected and preserved is retained in alcohol-filled vials for future study.

The ordinary method of estimating the volume is to place all the material from a single haul in a long graduated tube closed at the lower end, and after twenty-four hours of settling to read the volume in the tube as exactly as possible. It is evident that a very loose flocculent plankton will settle less rapidly than a denser mass, and that both will show irregularities rendering the reading hardly more than an approximation. This volumetric method is thus somewhat inexact, but probably correct within reasonable limits. It has the advantage of comparative rapidity, and since the material remains under alcohol during the entire process it suffers no injury. The gravimetric method, advocated by some investigators, consists in drying and weighing the entire mass of a plankton haul, and this is held to be more exact than the previous method. Great difficulty is found in weighing just at the time when all the external water is driven off, but when that which enters into structure is retained. The fatal objection to the method is, however, that the material when once dried is useless for further study. I have proposed a combination of the two methods which will be valuable in certain cases, but in general the volumetric is no doubt sufficiently accurate.

The qualitative determination of a haul may be made by a method of approximation or by enumeration. In the first case the plankton is poured into a very shallow dish, and the observer estimates the percentage of each species present. Such a procedure gives but a very general idea and evidently depends entirely upon the judgment of the observer. In the other method the total amount of a haul is diluted with alcohol to a fixed volume, then thoroughly shaken up and three small tests, of 1 cc., for instance, removed at random, spread upon a ruled plate, and the number of each species actually counted under the microscope. By averaging the three sample tests and by multiplying the result the total number of the species found in the haul is estimated. The amount of labor involved in laboriously counting for each of the twenty to one hundred species in each plankton haul is enormous, and yet for the determination of the relative importance of the various elements it seems to be necessary. For the plankton of Lake St. Clair and Lake Michigan this part of the work has not yet been done.

One further process is necessary. The results of the calculations just described are characteristic only for the particular net used and at the actual velocity, and it is necessary to express them in some more general terms. This may be done by multiplying by a correction such as to give the amount of plankton under one square meter of surface; the result will be the total amount contained in a column of water one meter square with a height equal to the depth of the haul. If, now, this be divided by the depth of the haul, the result will be the average amount of plankton per cubic meter of water, or the relative amount at the place and time of making the haul.

In Lake St. Clair there were made twenty-seven bottom hauls, two from each station except the first; the amount of plankton per cubic meter of water obtained in each haul is in the following table:

NO. OF STATION.	I	II	III	IV	V	VI	VII	VIII	IX	X	XIII	XIV	XV	XVI	AV.
Volume of plankton in cubic centimeters per cubic meter of water	4.97	1.44 2.68	2.76 3.89	2.01 2.01	2.74 3.62	2.29 3.08	3.69 3.69	2.70 3.01	2.54 2.39	4.15 4.15	4.79 3.97	3.60 3.31	1.80 2.42	1.90 2.33	3.03

From Lake Michigan, near Charlevoix, eighteen bottom hauls show the following results:

NO. OF STATION.	I	II	III	IV	IX	X	XI	XII	XIII	XIV	XV	XVI	XVII	XVIII	XX	XXI	XXII	AV.
Volume of plankton in cubic centimeters per cubic meter of water	1.64	3.82 3.20	2.70	4.91	4.46	2.01	1.52	5.68	4.77	8.16	5.34	5.38	1.23	2.49	2.68	4.03	2.41	3.69

In Round and Pine lakes, two connecting inland lakes which have immediate and free connection with Lake Michigan at Charlevoix, the following amounts were obtained in nine bottom hauls:

NO. OF STATION.	V	VI	VII	VIII	XXIII	XXIV	XXV	XXVI	AV.
Volume of plankton in cubic centimeters per cubic meter of waters	2.88	2.28	3.14	5.84 5.27	3.96	6.88	3.17	2.34	3.97

In comparison with other lakes which have been measured in Germany, all of these are very poor in plankton, Dobersdorfer See, containing, for example, as much as 62.1 cc. of plankton per cubic meter of water. And yet the small amount which is present constitutes *in toto* a tremendous mass. The estimated volume of Lake Michigan is about 7,434 millions of cubic meters, and if the average of the lake contain an amount of plankton only equal to the least amount in any bottom haul at Charlevoix, it would make a solid mass of plankton in the entire lake of over *eleven thousand cubic meters.*

The distribution of this mass is of the greatest practical moment in fish culture, and here are contained in fact three problems: (1) seasonal, (2) areal, (3) vertical distribution. It is evident that only long continued observations in the same region can throw light on the question of seasonable distribution. Studies on lakes in Holstein are the source of our present knowledge; they show a minimum in February and a maximum in September, connected by a variable line of increase and decrease. The results of consecutive years exhibit marked differences in the extremes, both as to time and amount, and yet there is a general agreement in the increase of life with rising temperature and decrease with the lowering of the same.

Areal or horizontal distribution must be determined by comparison of observations made within a limited time, since throughout the year there is, as already explained, a progressive variation due to other causes. The series of hauls made at St. Clair and Charlevoix are peculiarly adapted to throw light on this question, since each series falls within a period of less than two weeks and both were made also at about the same season of the year. The results of the work at Charlevoix, which covered the greater variety of conditions in depth, distance from shore, and number of hauls, are represented graphically on plates I. and II. Each vertical line represents a station, and on it are set off on plate I. the depth of the haul, the total volume, and the volume per cubic meter of water. By connecting similar points, lines are produced which represent the changes of these elements from station to station. The various stations are arranged in order of depth with the shallowest at the right so that the dotted line of depth (D) continually descends toward the left. Considering first the conditions in Lake Michigan (1 *A*) it is evident that the line of total volumes (T) shows a rapid increase at first, then a region of uncertain fluctuation in which the greatest variation (XIX) is undoubtedly due to the presence of foreign matter,* and finally a second decided increase with the sharp plunge downward of the line of depth. Compare these two lines; the total volume increases at first more rapidly and in the last half of its course less rapidly than the depth. The line of relative volume, *i. e.*, volume per cubic meter of water (R), steadily ascends towards the left. One station alone (XIX) excepted, it swerves but little from the fine dotted line which connects its two ends and which may be said to indicate the average tendency: Compared with the line of depth it is clear that the relative volume decreases steadily with increasing depth of water. On plate I. *B* are represented in the same way the results of a smaller number of hauls in the two inland lakes of the Charlevoix region already mentioned. An examination of the lines shows that the principles already demonstrated for the great lake hold true in general here also. It may be that the more limited environment of the smaller area and shallower water introduces other factors and gives rise in this way to the apparently greater irregularities in this case. Comparing the results from Round and Pine lakes with those from equal depths in Lake Michigan (I. *A*) it is evident that excepting the two shallowest stations, the great lake possesses a much larger amount of plankton. It is an interesting indication of the limited food supply in Pine lake, especially that very few fish are found in its waters while adjacent lakes are well populated.

The table of bottom hauls from Lake St. Clair, given on page 115, is strong evidence that at the same point the amount of plankton to be obtained at any time is comparatively uniform. Two bottom hauls were made at each station after the first. These two were separated by a considerable time interval. Now, if the plankton were massed in so called "swarms," it would be altogether probable that the two hauls would in a number of cases be decidedly different in amount according as they included a swarm or only the more barren interspaces. But the table shows that many of the pairs agree exactly, and that ninety per cent of them do not differ from each other by so much as one-fifth. Again, among the hauls in Lake Michigan (Plate I. *A*) there is only one, XIX, which shows any considerable difference from those made at equal, or nearly equal, depths, and this one, XIX., owes its extreme volume, as already mentioned, to the presence of a quantity of foreign matter (sand) carried into the net by some accident. This evidence may fairly be regarded as establishing for the same body of water the principle of equal amounts of plankton at equal depths.

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*The fine dotted line from XVIII to XX represents more nearly the true volume.

In determining the vertical distribution of plankton, two methods are possible. A closable net may be sunk to any depth, opened, drawn up a given distance, and then closed and brought to the surface. The amount of plankton included is, then, that which was in the part of the water through which the net passed while open. Such a method would be the most exact, but closable nets are more difficult to manipulate and sometimes unreliable, so that the method of subtraction is more often employed. At each station hauls are made from a series of depths; 2, 5, 10, 25, 50, and 100 meters were the artificial strata made in the Charlevoix work, each series being concluded or interrupted by a haul from the bottom to the next higher limit. By this means the following amounts were obtained from Lake Michigan. The figures represent in all the tables cubic centimeters of volume:

No. of station	IX	X	XI	XIII	XV	XVI	XVII	XVIII	XIX	XX	XXI	XXII
2 m.-surface	19.4	18.5	22.1	28.4	25.3	27.2	23.4	26.3	25.7	18.5	23.2	17.7
5 m.-surface	40.7	26.3	35.3	41.6	31.1	42.4	44.4	33.7	34.9	31.7	35.1	25.0
10 m.-surface	54.7	47.8	66.6	79.6	53.4	80.9	88.7	49.2	58.8	49.6	50.3	49.4
25 m.-surface	117.3	96.8	115.5	169.2	------	126.3	159.3	90.1	118.5	82.9	88.7	75.8
50 m.-surface	116.0	106.8	157.8	143.2	------	------	179.2	89.6	?	110.1	------	101.4
Bottom-surface	------	------	170.3	------	------	------	168.0	------	------	------	------	------
Depth of bottom haul in meters	26	53	111	30	10	23.5	130	36	36	41	22	42

By subtracting consecutive hauls at any station the amounts in the several artificial strata are secured.

No. of station	IX	X	XI	XIII	XV	XVI	XVII	XVIII	XIX	XX	XXI	XXII
2 m.-surface	19.4	18.5	22.1	28.4	25.3	27.2	23.4	26.3	25.7	18.5	23.2	17.7
5 m.-2 m.	21.4	7.8	13.2	13.2	5.8	15.2	21.0	7.4	9.2	13.2	11.9	7.2
10 m.-5 m.	13.9	21.5	31.3	38.0	22.3	38.6	44.3	15.6	23.9	17.9	15.2	24.4
25 m -10 m.	62.6	49.1	48.9	89.6	------	45.4	70.6	40.9	59.7	33.3	38.4	26.4
50 m.-25 m.	-1.3	10.0	42.4	-26.1	------	------	19.9	-0.5	?	27.2	------	25.5
Bottom-50 m.	------	------	12.5	------	------	------	-18.8	------	------	------	------	------

Dividing the amount in each stratum by the thickness of the stratum in meters, the result will represent the amount of plankton per cubic meter of water in each of the artificial strata.

No. of station	IX	X	XI	XIII	XV	XVI	XVII	XVIII	XIX	XX	XXI	XXII	AV.
2 m.-surface	9.7	9.2	11.0	14.2	12.7	13.6	11.7	13.1	12.9	9.2	11.6	8.9	11.5
5 m.-2 m.	7.1	2.6	4.4	4.4	1.9	5.1	7.0	2.5	3.1	4.4	4.0	2.4	4.8
10 m.-5 m.	2.8	4.3	6.3	7.6	4.5	7.7	8.9	3.1	4.8	3.6	3.0	4.9	5.1
25 m.-10 m.	4.2	3.3	3.3	6.0	------	3.0	4.7	2.7	4.0	2.2	2.6	1.8	3.2
50 m.-25 m.	-1.3	0.4	1.7	-5.2	------	------	0.8	0.0	?	1.7	------	1.5	-0.1
Bottom-50 m.	------	------	0.2	------	------	------	-0.2	------	------	------	------	------	0.0

These results for Lake Michigan are expressed graphically in Plate II. *A;* the other part of the plate (II. *B)* shows like results from Round and Pine lakes. The line of depth *(D)* is the same as on Plate I. The amount of plankton per cubic meter of water in the surface stratum, as shown by the line *S—S*, is far greater than that in any other stratum. The amount is variable; and its fluctuations seem on comparison of the lines to be independent: (1) of the depth, (2) of the total volume, (3) of the time of day,* (4) of the temperature of the water.*

It may be that the variations in the amount of plankton present in the surface stratum are due to the combination of two or more of the factors cited; but their independence of any one factor can easily be seen by noting the number of cases of opposite trend in the lines.

In the work in Lake St. Clair it was also shown that the surface stratum contained from one and one-quarter to two times as great a volume of plankton per cubic meter of water as any other part of the depth which was, to be sure, inconsiderable—not exceeding 5.5 meters. The same holds true for the lakes in Holstein, and may probably be regarded as a fundamental principle in the vertical distribution of the plankton. While the plankton is most closely massed in the superficial stratum of two meters, it is still not to be found at the immediate surface in the day time. A net of special construction was towed just at the surface of the water for hours during the trips of our boat at Charlevoix and never made a "catch" of appreciable volume during the hours of the day; but when towing was tried after nightfall at the same depth a large amount was taken. It is probable that a daily migration takes place which carries the mass of the surface plankton down a short distance in the day time and brings it back to the immediate surface with the coming of darkness.

The three intermediate strata, 2-5 m., 5-10 m., and 10-25 m., possess on the average about the same amount of plankton per cubic meter of water. The amount found in any one of them varies exceedingly, and each has at certain stations more than either of the others. Curiously the upper of the three strata (2-5 m.) has, for nearly all stations, less than the middle stratum, and only about the same as the lower (10-25 m.). It is perhaps true that the upper and the lower vary in accord with each other in general; their variations are apparently independent of the depth or other factors at hand. There is an interesting parallelism in the lines representing the surface stratum and that from 5 to 10 meters; but for this no cause can be assigned as yet. Only one of these lines is above the zero line of the plate, that is, indicates a quantity of plankton less than nothing! It is the 2-5 m. line at the shallowest station, where this is the bottom stratum. The apparent absurdity of a quantity of plankton with the minus sign is one of the minor disadvantages of the subtraction method; it is possible only when the minimum amount of plankton in a given stratum is less than the possible fluctuations in the amount of plankton contained in the superjacent water, and it indicates that the amount probably present in the stratum was insignificant.

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* The last two points are not shown on the plates given in this article.

The lines denoting the intermediate strata lie in all cases clearly below the lines of the deep strata, 50-25 m., and bottom—50 m.; the latter never equal to the former and in a large per cent of cases the amount of plankton seems to be a negative quantity. This is indicated by the position of the 25-50 m. line above the zero horizontal at IX., XIII., and XVIII. In the case of the deepest stratum, which was present in but two instances, the amount of plankton obtained was even more insignificant. The deep strata are practically without plankton so far as our observation extended.

One question in the distribution of life in these waters which was not studied, is the possible existence of a deep fauna, not strictly planktonic in character, but dependent in fact upon the bottom, where it rests and reproduces, and frequently making short excursions into the superjacent water. It would thus be dependent for support on the plankton and would frequently be collected with the latter, but would be no proper portion of it.

If this be in rough outline the distribution of the plankton as a whole, it will be seen at a glance that this is merely the beginning of the problem. The distribution of the whole is no more than the sum of the distributions of its many species. In so far as the variations in the volume of the different strata, so clearly marked on the maps, are not produced by errors in apparatus and method, they are due, no doubt, to fluctuations in the location of certain species. Such changes are known to be brought about in isolated instances by change in temperature and light; how far these influences are operative in carrying an unknown species from one side to the other of the artificial limits we have placed in the water, and in thus modifying the qualitative and quantitative composition of the plankton in any particular stratum—these are but suggestions of the many questions awaiting a solution.

The investigation of plankton problems has only just begun; yet hand in hand with these studies goes the practical application of the results obtained. It would be impracticable to explain here the light that they throw on the probable life of the young fish and the precautions to be observed in planting the fry; the subject must be left with the mere hint. Already efforts have been made on a small scale at least to increase the primitive food supply, and in some small fish ponds in Europe it has met with moderate success. No one can predict the possibilities of the future; these studies have made one of its necessities evident and imperative. Aquaculture must be given the same sort of broad, scientific treatment that agriculture already receives; it must be studied from the scientific standpoint, its problems analyzed, its course marked out with definiteness. Not until then can it hope to render that service to the people which the unequalled opportunity of our inland seas makes possible in the way of a permanent supply of food at once cheap and agreeable.

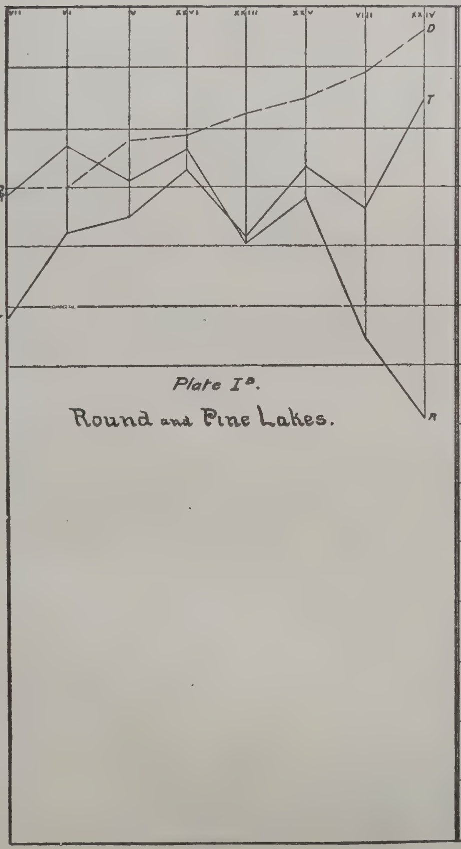


Plate I^b.

Round and Pine Lakes.

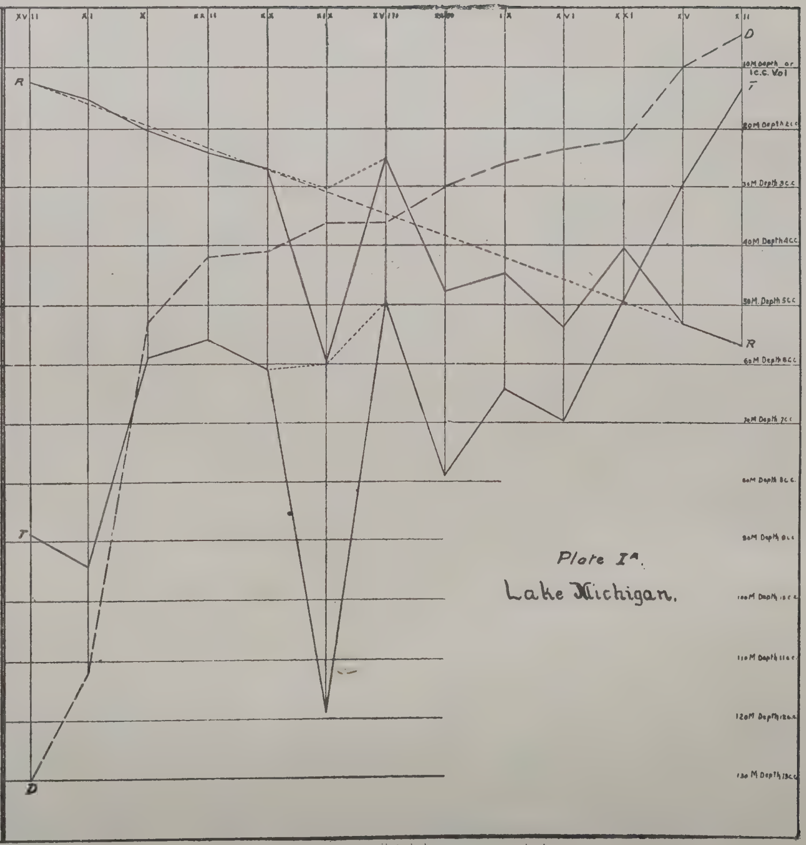


Plate I^a.

Lake Michigan.

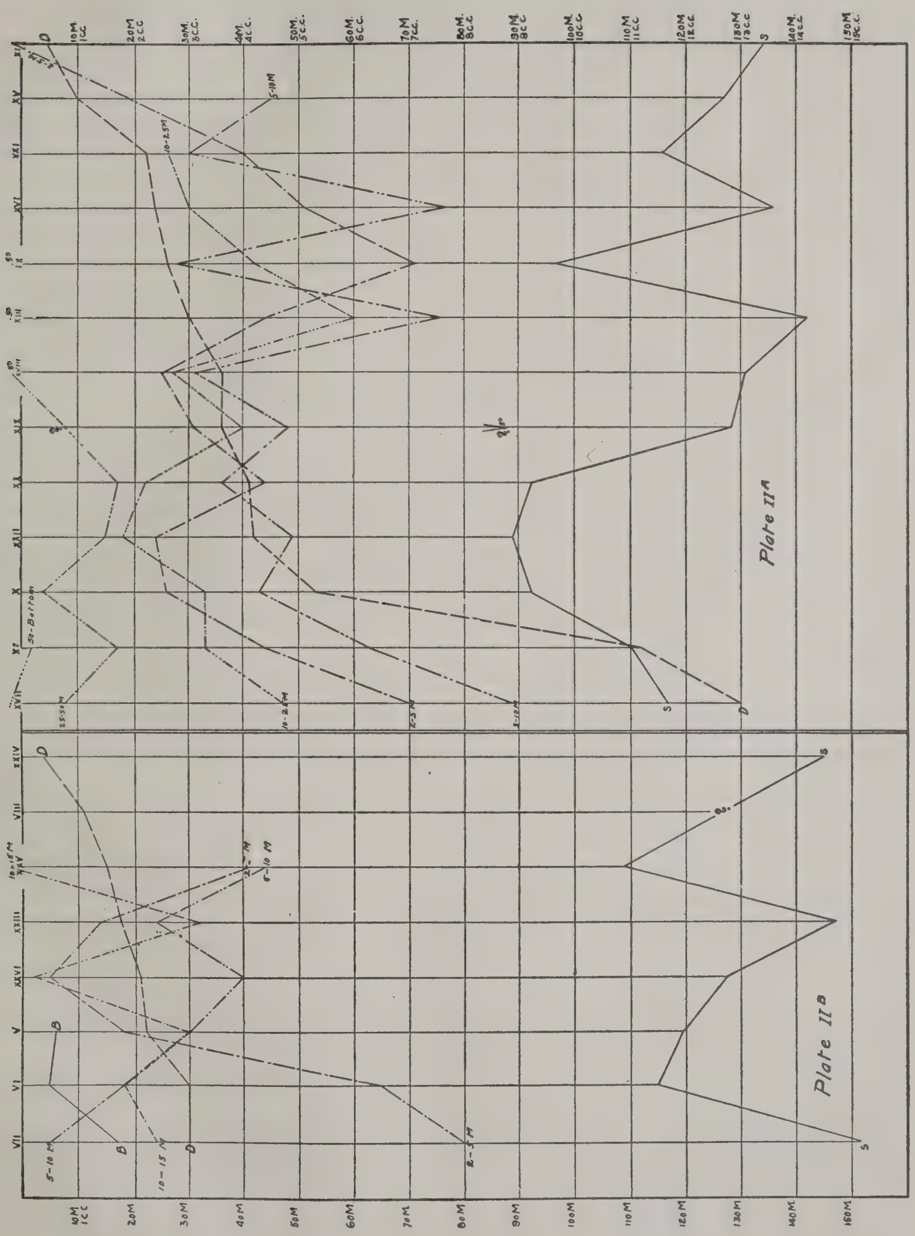


Plate IIA
Plate IIB
10M 1CC
20M 2CC
30M 3CC
40M 4CC
50M 5CC
60M 6CC
70M 7CC
80M 8CC
90M 9CC
100M 10CC
110M 11CC
120M 12CC
130M 13CC
140M 14CC
150M 15CC
XIV
XV
XXI
XVI
IX
XIII
XVIII
XIX
XX
XXII
X
XI
XVII
XXIV
VIII
XXV
XXIII
XXVI
V
VI
VII
50-Bottom
25-50M
10-25M
2-5M
5-10M
10-15M
D
S
B

FISH PRESERVATION AND FISH CULTURE IN NORTH AMERICA.

EXTRACTS FROM MR. OSCAR NORDQVIST'S OFFICIAL REPORT TO THE IMPERIAL SENATE OF FINLAND.

After a week's stay in Put-in-Bay, I went to Detroit, Michigan, the headquarters of the Michigan State Fish Commission. The city is situated on the river forming the connection between Lakes Huron and Erie, and has an extensive hatchery here for hatching whitefish and pike perch, which is the largest institution of the kind in the world. Over one hundred millions of young whitefish are turned out there in one year.

In Detroit I made the acquaintance of the energetic Fish Commissioner of Michigan, Mr. Herschel Whitaker, who gave me valuable and manifold information about the work of the commission, and especially the cultivating of fish, including literature, photographs, etc.

On my way to Paris I also visited the State Commission's station for the gathering of pike perch spawn at Saginaw Bay, on the shore of Lake Huron. Owing to stormy weather just then prevailing, the fishermen could not show me the manipulation of the weirs and the other tackle, but I witnessed and took practical part in the artificial impregnation of pike perch spawn from fish kept there for this spawning purpose. I also observed a process to prevent the eggs from adhering by adding starch to the spawn after a method invented by Prof. Reighard, by which the results of impregnation are considerably increased.

In parts of the United States yearly statistics of fishermen are gathered and published. In the State of Michigan every person pursuing the vocation of a fisherman on the Great Lakes is bound to furnish a report every year by filling out blanks which the commission has prepared for the purpose. As this provision, however, does not naturally prevent negligence on the part of fishermen, the State Fish Commission employs a special agent whose duty it is to visit the fishermen and enforce the statutes of the fish laws regarding these reports as required. Furthermore the agent is to gather information with all possible exactness about the important and precise places frequented by the different kind of fish as spawning beds; whether the conditions of fishing are improving or declining in particular localities; the fishermen's opinions as to the cause of respective changes; whether the water has been polluted by offal from factories or similar refuse, and if so, the resulting extent of injury to the fishery; what propositions or recommendations with reference to an improvement of conditions the fishermen might make; in what way and for what period they would recommend a closed season for whitefish; whether artificial propagation helped the fisheries and if so, by what means such fact had been ascertained; whether there should be any restrictions as to the size of nets or meshes; and finally, whether persons conducting fishing on a large scale would be willing and able to attend conferences for the promotion of the interests of the fisheries.

In the year 1893 the Michigan Fish Commission established a biological station in Lake St. Clair for special scientific research pertaining to the improvement of fisheries and fish culture. This institution is superintended by Prof. J. E. Reighard, whose endeavors were hitherto mainly devoted to the alimentary resources for fish in Lake St. Clair.

In connection with this scientific work I will also mention the systematic researches of the Fish Commission concerning the results of fish culture in the State of Michigan. For this purpose the commission keeps special employés. Their duty consists in investigating the lakes as to dimensions and depth, the conditions of bottoms and banks, of inlets and outlets, the temperature of the surface and ground water and the kind of fish that frequent it. These data, together with notes on the weather, the exact time of investigation and the tackle used during the researches after the different kinds of fish, etc., are entered on printed blanks, which contain also a special column for remarks about the most desirable species for stocking purposes.

In many thousand streams where there were no brook trout it is now acclimated, thanks to the work of cultivation. Take the State of Michigan, for instance; there the following number of brook trout fry has been hatched between 1883 and 1892:

1883	269,000
1884	383,000
1885	408,000
1886	719,000
1887	1,090,000
1888	1,639,000
1889	2,468,000
1890	2,578,000
1891	2,500,000
1892	2,252,000

The Michigan Fish Commission plants the young brook trout at the time of absorption of the yolk sac.

This work of cultivation produced very satisfactory results. Previous to it brook trout were very scarce and only occasionally met with in a few streams of the lower peninsula; now it affords good angling in two-thirds of all the counties of the entire State.

The State fish laws absolutely forbid the catching of brook trout in any water artificially stocked with it by the State Commission within three years from the date of stocking. The enforcement of this law brought it about that between the 1st of May of 1890 and 1892 700 streams stocked by the commission were opened to the catching of brook trout. Altogether there are about 2,000 streams open now for brook trout catching where this fish had been artificially introduced.

Of all the fish subjected to the experiment none has been cultivated on such a large scale as the whitefish on account of its great economical importance surpassing that of any other fresh water fish.

Among the several varieties of whitefish found in American waters, the common whitefish (*coregonus clupeiformis*) and the lake herring (*coregonus artedi*) are by reason of their abundance the most important for economical purposes, the former taking precedence over the latter. That will account for the fact that until recently the common whitefish constituted the almost exclusive object for cultivation. Both varieties are taken in the Great Lakes and in Canada, although the northern boundary line of their habitat has not as yet been ascertained.

This work found a powerful support with the Michigan State Fish Commission, whose whitefish and pike perch hatchery in Detroit is the largest of its kind on the entire globe.

The states of Pennsylvania, Ohio and New York contributed their share likewise in helping the propagation of whitefish by planting millions of fry every year.

Next to the United States and the Michigan State Fish Commissions as to the importance and magnitude of the work done, ranks the Department of Fisheries of the Canadian Government. In 1891 the department planted 451,380,000 whitefish fry.

As not all of the reports of the different states were accessible to me, I find it impossible to state the exact amount of whitefish fry hatched and planted on and in the Great Lakes. The approximate estimate of the combined output of the United States and Canada in distributed young whitefish should, in my opinion, be placed at about two milliards.

The Michigan State Fish Commission started pike perch culture in its own hatchery in 1887; the output has steadily increased ever since as shown by the following table:

1887	3,280,000 fry.
1888	11,492,000 fry.
1889	44,340,000 fry.
1890	22,300,000 fry.
1891	27,045,000 fry.

At the meeting of the American Fisheries Society in Chicago in 1893, Prof. Reighard related an experiment undertaken at the request of the Michigan State Fish Commission for the purpose of finding a suitable means to prevent the cleaving (adhesion) of pike perch eggs. The Professor pointed out the following ways as suggesting themselves upon the experimenter:

1. Some substance might be found which after being dissolved in the water over the spawn would destroy the tendency to adhere of the outer membrane of the eggs without injuring the ova or milt. Different substances were tried but with poor results.

2. The eggs may be allowed to adhere so as to form clusters, and may afterwards be separated by mechanical means as, for instance, by letting them pass through a sieve. The eggs, however, through the pressure against each other, will change their shape and some of them will be destroyed.

3. Some substance may be introduced in the water which will penetrate the spawn in such a manner as to prevent the eggs from touching each other. After trying numerous substances in vain, Prof. Reighard obtained good results by using corn starch.

One part of starch was mixed with 20 parts of water. The eggs were impregnated in the usual way; after two to three minutes they are immersed in the starch solution until the latter is half filled with spawn. The eggs sink to the bottom of the receptacle and become covered with the starch which prevents their cleaving together. Thus they are allowed to remain undisturbed and the injurious effect of moving is avoided. After having been immersed for a while in the solution, they are suddenly transferred into an abundance of clear water; the milt is almost instantly washed off and the surface of the eggs thus cleaned from adhering alkaloids.

The starch sinks gradually; within ten minutes most of it is deposited on the bottom of the vessel. The water is then replaced by fresh water; by shaking or swinging the vessel, starch and eggs are mixed with the fresh water. After the starch has settled again a new fresh water change may be effected. In this way the water may be renewed every ten minutes, if deemed necessary, and without adding new starch. The eggs may remain in the starch solution for four hours or more, but usually they were washed clean after two hours. After that they appeared well filled and of normal form, and when transferred to fresh water they did not stick.

The starch seems to have no influence other than to prevent the eggs from cleaving. Eggs treated after this manner showed an increase in impregnation of from 15 to 30 per cent, compared with the old method. Mr. Dwight Lydell of the Michigan Fish Commission, who carried on these experiments, on a large scale, showed that this application of corn starch increased impregnation of pike perch eggs by about 20 per cent.

Prof. Reighard's process must be greeted as a valuable discovery of special importance in fish impregnation, in fact as the only important one since the discovery of dry fish impregnation by the Russian fish cultivator, Wrassky, which is now in use nearly throughout the entire world.

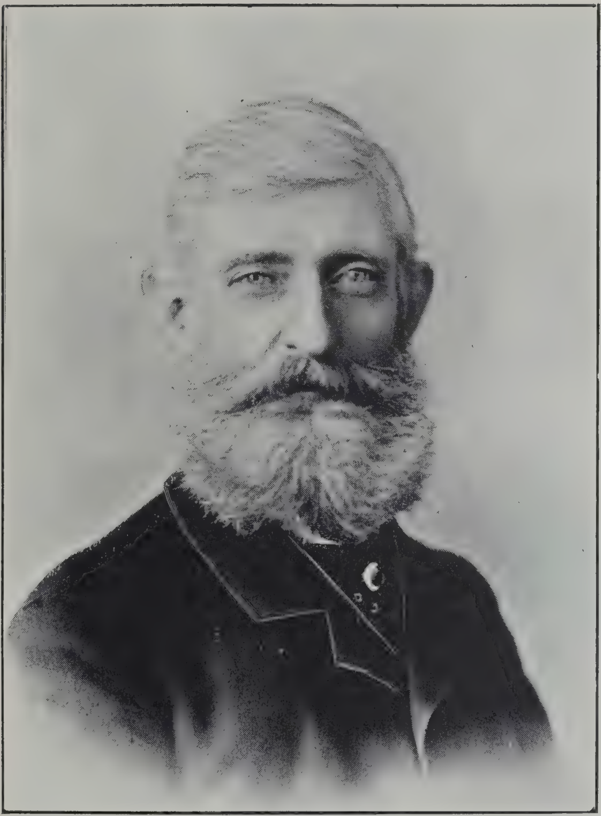
After the experiments in cultivating living food, undertaken successfully by a few European hatcheries, the Americans began to follow in their wake during the last few years. But whoever had had the occasion to observe the vigor and perseverance shown by the Americans in the work of fish cultivation, must certainly feel convinced, that within a short time they will also be masters in this new branch and will develop and complete new methods.

Methinks I could not do better in rendering my concluding impressions than to quote from the 10th Annual Report of the Michigan State Fish Commission the following:

“Considering that the first successful attempts at fish cultivation
“ have occurred within a lapse of time still remembered by many living
“ persons, the progress made and the results obtained may indeed appear
“ as next to marvellous.”

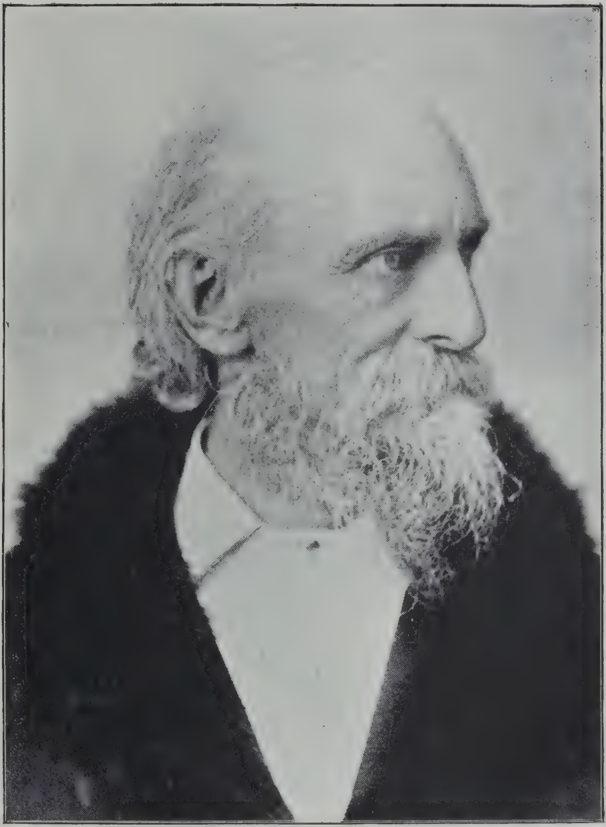
OSCAR NORDQVIST,
Helsingfors, Finland.

October 1895.



ANDREW J. KELLOGG, COMMISSIONER.
1874 TO 1884.

ELI R. MILLER, Commissioner.
1875 to 1883.



J. C. PARKER, COMMISSIONER.
1877 TO 1893.

JOHN H. BISSELL, COMMISSIONER.
1883 TO 1889.

HOYT POST, COMMISSIONER.
1889 TO 1895.

Bulletin of the Michigan Fish Commission

No. 5.

ON THE

CYCLOPIDÆ AND CALANIDÆ OF LAKE ST. CLAIR,

LAKE MICHIGAN, AND CERTAIN OF THE INLAND LAKES OF MICHIGAN.

By C. Dwight Marsh,
Professor of Biology in Ripon College.

Results of a Biological Examination of Lake St. Clair Undertaken For the State Board of Fish Commissioners in the Summer of 1893 under the Supervision of J. E. Reighard, and of Similar Work in the Summer of 1894, in the Vicinity of Charlevoix under the Supervision of H. B. Ward.

LANSING:
ROBERT SMITH & CO., STATE PRINTERS AND BINDERS,
1895.

ON THE CYCLOPIDÆ AND CALANIDÆ OF LAKE ST. CLAIR, LAKE MICHIGAN, AND CERTAIN OF THE INLAND LAKES OF MICHIGAN.

From the standpoint of the pisciculturist, perhaps no class of animals outside the fishes themselves is so important and interesting as the entomostraca. It is a well known fact that these minute crustacea form the entire food material of the young of some of our most important food fishes, and in many cases form a large part of the food of the adults.

They are universally distributed. Every stream, lake, pond, and pool has its population of these minute creatures. Moreover they are present in some places in enormous numbers. In the deeper waters of our lakes the surface waters to a depth of about thirty feet fairly swarm with copepods. In limnetic collections there are always present some *Cladocera*, but the great bulk of the material in any lake will consist of two or three species of *Diaptomus* and as many of *Cyclops*.

Inasmuch as the occurrence and abundance of animals is largely dependent on their food supply, it will be seen that an accurate and thorough knowledge of entomostraca is of fundamental importance, if we would have an exact knowledge of the conditions controlling our fish.

The material on which this paper is based was obtained from the following sources.

1. Collections made by Professor Reighard in certain lakes in southern Michigan in the summers of 1891 and 1893.
2. Collections made by Professor Reighard in the northern part of Lake Michigan in the spring of 1893.
3. Collections made by Professor Reighard during the biological examination of Lake St. Clair in the summer of 1893. This involved a very large number of collections in the months of July and August, and its results probably give us a very accurate knowledge of the copepod fauna of Lake St. Clair in the summer season. In connection with this work a few collections were also made in the Detroit river and in Lake Erie.
4. Collections made in July and August 1894 in connection with the scientific work of the Michigan Fish Commission at Charlevoix. This involved a careful examination of Round Lake and Pine Lake, collections in Lake Michigan and the lakes on Beaver Island, and cursory examinations of the small lakes in the neighborhood of Charlevoix.

5. Collections made by Dr. R. H. Ward in September, 1894, in Emmet and Cheboygan Counties, along the "Inland Route."

Inasmuch as these collections were made for the most part, in the summer season, and more especial attention was paid to the larger bodies of water, the results of the examination cannot be considered as giving us a complete knowledge of the fauna of the State. A more careful examination of the smaller lakes and of the stagnant pools would doubtless add some species to the list. Yet the number of those species would be small, and for the larger bodies of water the list as given in this paper is probably very nearly complete.

This becomes evident when one remembers how nearly identical are the faunæ of the deeper waters of our lakes. To such an extent is this true that one can prophesy quite exactly what species will be found in a collection from any of the lakes of this latitude. The collections from the deeper water will almost invariably give the following species:—*Diaptomus oregonensis*, *Cyclops brevispinosus*, *C. Leuckarti and C. fluviatilis. C. albidus* and *C. serrulatus* may be present, but belong more properly to the littoral fauna. In the larger lakes, in addition to this list we may find *Epischura lacustris*. *Diaptomus sicilis*, *D. Ashlandi*, *D. minutus*, and *Limnocalanus macrurus* are not commonly found except in the Great Lakes and in the bodies of water in direct connection with them; in the Great Lakes, too, *C. pulchellus* takes the place which *C. brevispinosus* holds in the smaller lakes.

D. Reighardi is the only new species which I have found in the Michigan collections. As I have already remarked in a former paper ('93 p. 192) the species of *Diaptomus* are, in some cases, quite limited in their distribution, and apparently *Diaptomus* is much more susceptible to the influences of its environment than is *Cyclops*. Very little is known of the life histories of the species of *Diaptomus*, and it is possible that a more complete knowledge may lead to a reduction of the number of species. But, so far as I can see, all the forms described vary within comparatively narrow limits, and there is no evidence whatever to lead us to question the separation of the forms.

I have indicated, in the accompanying chart, the distribution of the species. It has not seemed necessary to indicate the character of the individual collections in Lake St. Clair and Lake Michigan as no particular significance is attached to such facts.

The sketch maps will show most of the localities where the collections were made.

It is interesting to note the greater richness of the copepod faunæ of our lakes as compared with those of the continent of Europe. Zacharias finds seven species of copepods belonging to the *Cyclopidæ* and *Calanidæ* in the Plöner See. In Lake Michigan there are nine, and that includes no littoral species; in the lakes on the Beaver Island there are eight, in Pine Lake nine, in Round Lake eleven, in Intermediate Lake eleven, and in Lake St. Clair sixteen. The large number in Lake St. Clair is probably explained by the fact that, being very shallow, it has the species of the smaller bodies of water and of the stagnant pools, and in addition, because of its connection with the Great Lakes, has also their limnetic species.

Table of occurrence of Cyclopidæ and Calanidæ.

	Lake near Baldwin.	Bear Lake, Charlevoix County.	Beaver Island, North Lake.	Beaver Island, South Lake.	Black or Round Lake, Emmet County.	Burt Lake, Cheboygan County.	Carp Lake, Emmet County.	Crooked Lake, Emmet County.	Detroit River.	Dodge Creek, Cheboygan County.	Lake Erie.	Indian River, Cheboygan County.	Intermediate Lake, Antrim County.	Long Lake, Genesee County.	Long Lake, Ionia County.	Lake Michigan.	Mullet Lake, Cheboygan County.	Pickerel Lake, Emmet County.	Pigeon River, Cheboygan County.	Pine Lake, Charlevoix County.	Round Lake, Charlevoix County.	Lake St. Clair.	Susan Lake.	Twenty-sixth Lake.	Twin Lakes, Charlevoix County.
Diaptomus sicilis	----	----	----	----	----	----	----	----	+	----	----	----	----	----	----	+	----	----	----	+	----	+	----	----	----
" Ashlandi	----	----	----	----	----	----	----	----	+	----	----	----	----	----	----	+	----	----	----	+	+	+	----	----	----
" minutus	----	+	----	----	----	+	----	+	+	----	----	+	----	----	----	+	+	----	----	+	+	+	----	----	----
" Reighardi	----	----	+	----	----	----	----	+	----	----	----	----	+	----	----	----	----	----	----	----	----	----	----	----	----
" oregonensis	----	+	----	+	----	+	----	+	----	----	+	+	+	+	+	+	+	+	----	+	+	+	----	+	+
Epischura lacustris	----	+	----	+	----	----	+	+	----	----	+	+	----	+	+	+	+	----	----	+	+	+	----	----	----
Limnocalanus macrurus	----	----	----	----	----	----	----	----	+	----	----	----	----	----	----	+	----	----	----	----	----	+	----	----	----
Cyclops ater	----	----	----	----	----	----	----	----	----	----	----	----	+	----	----	----	----	----	----	----	+	+	+	+	----
" brevispinosus	+	+	+	+	+	----	+	+	+	----	+	----	+	----	----	----	----	+	----	----	+	+	+	----	----
" pulchellus	----	----	----	----	----	+	----	----	+	----	+	+	----	----	----	+	----	----	----	+	+	+	----	----	----
" parcus	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	+	----	----	----
" Leuckarti	----	+	----	+	+	+	+	+	----	----	+	+	+	----	+	+	+	+	----	+	+	+	----	----	+
" fuscus	----	----	----	----	----	----	----	----	----	----	----	----	+	----	----	----	----	----	----	----	----	----	----	----	----
" albidus	----	----	+	+	+	----	+	----	----	+	----	----	+	----	----	----	----	+	+	----	+	+	+	+	+
" fluviatilis	----	+	----	+	----	+	+	+	----	----	+	----	+	----	+	+	+	----	----	+	+	+	----	+	+
" serrulatus	+	+	+	+	+	----	+	+	+	+	----	+	+	----	----	----	----	+	+	----	+	+	+	+	+
" phaleratus	----	----	----	----	----	----	----	----	----	----	----	----	+	----	----	----	----	----	+	----	----	+	----	+	----
" bicolor	----	----	----	+	----	----	----	----	----	----	----	----	+	----	----	----	----	----	----	----	----	+	----	----	----

Pine Lake is peculiarly poor in its number of species. This is strikingly apparent when we compare it with Intermediate Lake. Pine Lake was very thoroughly examined, and it is likely that we are acquainted with all the species occurring there, and yet the number is only eight. All the collections from Intermediate Lake were made in one day by a party which went down from Charlevoix and remained only a few hours, and yet the number of different forms is eleven. Intermediate Lake seems to be an unusually rich collecting ground, for with the exception of Lake St. Clair and Round Lake, no other lake shows such a large number of species, and both Lake St. Clair and Round Lake have been very thoroughly explored. Moreover, in the case of Round Lake, several of the species may be considered as immigrants from Lake Michigan.

In general it may be said that the copepod fauna of Michigan does not differ materially from that of Wisconsin, which I have already described in a former report. (Marsh '93.) This is only what one would expect because of the very wide distribution of the species, as already noted. (Marsh '93, p. 191.)

Inasmuch as many of the species have been imperfectly described, it has seemed best to me in preparing this paper to devote some space to more detailed descriptions, and particularly to furnish some figures in addition to those already published, and in this way to supplement the work of preceding papers.

The literature of the *Copepoda* is so scattered that it is very difficult for any one except a specialist to make determinations of species that are at all satisfactory. Without doubt this fact has deterred many from attempting any study of the *Copepoda*. Much valuable work in regard to the distribution of species might be done by amateur investigators if there were any work giving brief directions by which the species might be determined with a fair degree of accuracy. This lack, with the advice of Professor Reighard, I have attempted to supply in the present paper. Preceding the notes on *Diaptomus* and *Cyclops*, I have given a brief synopsis of the species of those genera. These synopses, which, with some modifications, are like those in my paper on the copepods of Wisconsin, are intended simply to furnish a means of recognizing the species by some of their most obvious characters. While the first six plates may be considered as supplementing the work of my Wisconsin paper, I have thought best, in order to aid in the identification of species to add the seventh, which repeats some of the figures of the former paper. I think that by means of the synopses and plates, any one who has the patience to make the necessary dissections, will be able without much difficulty to identify our species of *Cyclops* and *Diaptomus*, at least as far as adult forms are concerned.

I have included in the synopses some species which have not yet been found in Michigan, but which have been reported from Wisconsin, and will, doubtless, after a more thorough exploration, be included in the Michigan fauna.

FAMILY CALANIDÆ.—Genus DIAPTOMUS Westwood.

KEY TO SPECIES OF DIAPTOMUS FROM CHARACTERISTICS OF THE MALE.

- Antepenultimate joint of antenna without appendage,
  - Fifth feet nearly equal in length, ---------------------- *oregonensis.*
  - Left fifth foot shorter than right,
    - Inner ramus of left fifth foot about equal in length to first joint of outer ramus, terminal hook of right foot not markedly angular, -------------------------- *pallidus.*
    - Inner ramus of left fifth foot about twice as long as first joint of outer ramus, terminal hook of right foot with an abrupt angle at about midway of its length, *Reighardi.*
- Antepenultimate joint of antenna with hyaline lamella, ---- *leptopus.*
- Antepenultimate joint of antenna with appendage,
  - Appendage short and blunt,
    - Left fifth foot hardly reaching end of basal joint of right, lateral spine of terminal joint of right foot weak, reaching about to end of joint, species large, occurring only in spring, ------------------------ *sanguineus.*
    - Left fifth foot reaching to about one-third the length of the terminal joint of the right, lateral spine of terminal joint large, reaching to nearly one-half the length of the terminal hook, ---------------------- *Birgei.*
  - Appendage as long or longer than the penultimate joint,
    - Terminal hook of right fifth foot broad, lateral spine minute, ---- ------------------------------------- *minutus.*
    - Terminal hook falciform,
      - Lateral spine nearer outer extremity of joint, ------- *sicilis.*
      - Lateral spine stout, nearer base of joint, ------------ *Ashlandi.*

Diaptomus sicilis Forbes.

Plate VII, figs. 1 and 11.

1882. *D. sicilis* Forbes, p. 645, pl. VIII, figs. 9 and 20.
1884. " " Herrick, p. 142, pl. Q, fig. 18.
1889. " " DeGuerne and Richard, p. 23, figs. 13 and 14, pl. II, fig. 13.
1891. " " Forbes, p. 702, pl. 1, fig. 6.
1893. " " Marsh, p. 197, pl. III, figs. 8 and 10.

D. sicilis is found everywhere in the Great Lakes, in Lake St. Clair and in the Detroit River. It is also found in Pine Lake, and very likely occurs in other bodies of water having direct connection with the Great Lakes.

I do not know of its occurrence in bodies of water away from the Great Lakes, except in Green Lake (Marsh '91 and '93), and Lake Geneva (Forbes, '90), and both of these are deep-water lakes.

Diaptomus Ashlandi Marsh.

Plate VII, fig. 2.

1893. *D. Ashlandi* Marsh, p. 198, pl. III, figs. 11–13.

When I described this species in my paper on the *Cyclopidæ* and *Calanidæ* of Wisconsin, I knew of only two localities for it, Lake Superior and Lake Erie. It occurred in the collections from Lake St. Clair and the Detroit River, but not abundantly. In the Lake Michigan collections it was a common species, but not nearly so numerous as *D. minutus.* I found it in none of the smaller lakes except Round Lake and Pine Lake.

DIAPTOMUS MINUTUS Lilljeborg.

Plate VII, fig 3.

1889. *D. minutus* DeGuerne and Richard, (Lilljeborg) p. 50, pl. I, figs. 5, 6 and 14, pl. III, fig. 25.
1891. *D. sicilis var. imperfectus* Forbes, p. 703.
1891. " " Marsh, p. 212.
1893. " " Marsh, p. 199, pl. IV, figs. 1 to 3.

D. minutus is, perhaps, the most common of all the *Diaptomi* in the collections from Lake St. Clair and the Great Lakes. With *D. sicilis* and *D. Ashlandi* it forms the great bulk of the crustacea in the limnetic collections. While I have found it in one or two of the Wisconsin lakes, it, like the two preceding species, has not so far been found in any of the Michigan waters which do not have direct connection with the Great Lakes. The three species may be fairly considered as characteristic of the fauna of the Great Lakes.

It is with considerable hesitation that I have considered Forbes's *imperfectus* identical with *minutus.* One can not be certain of the identity of the two forms from the description given by Forbes, and yet from the localities which he gives for his variety, it seems very probable that the two are the same. He speaks of it as common in Lake Superior and Lake Michigan, and in some adjacent lakes, and in Lake Geneva. Inasmuch as *D. minutus* is so common in the Great Lakes it is not at all probable that it has been overlooked by so accurate an observer as Professor Forbes, and as he reports *imperfectus* as an abundant form, I think the probabilities are that *imperfectus* is a synonym of *minutus.*

DIAPTOMUS OREGONENSIS Lilljeborg.

Plate VII, fig. 5.

1889. *D. oregonensis* DeGuerne and Richard, (Lillj.) pl. II, fig. 5, pl. III, fig. 8.
1893. " " Marsh, p. 200, pl. IV, figs. 4 and 5.

D. oregonensis is the common limnetic species of the smaller lakes. It occurs in the Great Lakes, but not abundantly, while in the smaller bodies of water it usually forms the larger part of the limnetic fauna.

DIAPTOMUS REIGHARDI, *sp. nov.*

Plate I, figs. 1-4.

The first segment of the cephalothorax is considerably shorter than the second. The first two segments form nearly half the length of the cephalothorax. The last segment is armed behind with two very minute spines.

The first segment of the abdomen of the female is elongated, nearly equal in length to the remainder of the abdomen and the furca. It is dilated laterally and in front and bears two rather small lateral spines. The second segment is about one-third shorter than the third. The third segment is slightly shorter than the furca.

The antennae reach the end of the furca. The right antenna of the male is swollen anterior to the geniculating joint; the antepenultimate joint has no appendage.

The outer ramus of the fifth foot of the female is two-jointed. The third joint is represented by the customary two spines. The inner ramus is one-jointed; it is somewhat longer than the first joint of the outer ramus, and is armed at tip with minute setæ and two spines.

In the right fifth foot of the male the basal joint is quadrangular, about one-half longer than broad. The length of the first joint of the outer ramus is about equal to its width. The second joint is elongate, concave on its inner margin; at about one-third of its length there is a minute spine on its inner margin; the rather long lateral spine is situated at about two thirds of its length. The terminal hook has a single abrupt angle at about one-half its length. The inner ramus is one-jointed and equals in length the first joint of the outer ramus.

The left fifth foot of the male reaches a little beyond the middle of the second joint of the outer ramus. The basal joint is about as broad as long, and is somewhat shorter than the basal joint of the right foot. The first joint of the outer ramus is about as broad as long, its distal end considerably narrower than the proximal. The second joint is about twice as long as the first, and the tip is expanded into two finger-like processes, of which the outer is much the larger and is armed on its inner surface with a pad bearing minute setæ. The inner ramus extends to rather less than one-half the length of the second joint of the outer ramus.

Length of female, 1.1395 mm.; male, 1.0248 mm.

This species, which is nearly related to *D. oregonensis*, is yet readily distinguished by the characters of the male fifth foot. I found it in the collections from only three localities,—the North Lake on Beaver Island, Intermediate Lake, and Crooked Lake.

I have named this species in honor of Professor Reighard who has, directly and indirectly, done so much to increase our knowledge of lacustrine faunæ.

GENUS EPISCHURA FORBES.

Plate II, figs. 1-6. Plate III, figs. 1-6.

EPISCHURA LACUSTRIS Forbes.

1844. *Scopiophora vagans* Pickering, p. 62.
1882. *E. lacustris* Forbes, pp. 541 and 648, pl. VIII, figs. 15, 16, 21, 23, pl. IX, fig. 8.
1884. *E. lacustris* Herrick, p. 131, pl. Q, fig. 13.
1889. " " DeGuerne and Richard, p. 90, pl. IV, figs. 3, 9 and 10.
1891. " " Forbes, p. 704, pl. I, figs. 1–5; pl. II, fig. 7.
1893. " " Marsh, p. 200, pl. IV, fig. 6.

I have very little doubt that, as stated by Herrick ('84, p. 131), the *Scopiophora vagans* of Pickering is the same as *E. lacustris.* The statement in regard to the armature of the abdominal furcæ can apply to no other genus, and as only one species of *Epischura* has been found in the Great Lakes, there would seem to be little doubt as to the identity of Pickering's species. If then we follow the laws of priority as strictly as do some authors, we should throw out Forbes's name. But I cannot think it wise when a name has been so long incorporated in our literature, and is founded on an accurate and easily recognized description, to throw it aside in favor of a name accompanied by a description which, it is true, probably applies to this animal, but is manifestly inaccurate in some particulars, and may be in all.

It is not necessary to give a detailed description of this species, as that has already been done by other authors, but, as very few figures of it have been published, it has seemed best to me to draw quite a number in order that they may serve for comparison of this genus with others, and of the various species of *Epischura* with each other.

A few points in the anatomy, which have not been noted by others should be mentioned.

Forbes has recently ('93, p. 255) called attention to the fact that the fourth abdominal segment of the male is without a process, and that the fifth bears two processes.

The antennæ are 25-jointed. In the female, clavate sensory setæ are present on all segments except the 4th, 6th, 8th, 10th, 20th, 21st, 22d and 24th. The 8th and 11th segments have each a short spine. The left antenna of the male is like those of the female except that the sensory setæ are much longer, particularly on the basal segments. The right antenna of the male is 22-jointed, with a hinge between the 18th and 19th segments. The 19th segment is formed by the union of the 19th, 20th and 21st of the typical antenna, and the 20th by the union of the 22d and 23d.

The outer rami of the swimming feet are three-jointed, and the inner one-jointed. In all the feet the inner ramus bears five setæ. In the first foot the first and second joints of the outer ramus have each one external and one internal seta. The terminal joint has six setæ. In the second, third, and fourth feet, the first and second joints of the outer ramus have spines externally instead of setæ as in the first foot. The terminal joint has two short spines externally, a long terminal spine with its outer margin deeply serrate, and four setæ on the internal margin.

E. lacustris was a common species in the collections from Lake St. Clair, Lake Michigan, and many of the smaller lakes.

GENUS LIMNOCALANUS SARS.

LIMNOCALANUS MACRURUS Sars.

Plate IV, figs. 1 and 2, Plate V, figs. 1-5.

1863. *L. macrurus* Sars., pp. 228-229.
1882. " " Forbes, p. 648.
1886. *Centropages Grimaldi* DeGuerne, pp. 1–10.
1888. *L. macrurus* Nordqvist, pp. 31–37, pl. I, figs. 9–11; pl. II, figs. 1–5; pl. III, figs. 1–4.
1889. *L. macrurus* DeGuerne and Richard, p. 77, pl. IV, figs. 5, 11, and 12.
1891. *L. macrurus* var. *auctus* Forbes, p. 706.
1893. " " Marsh, p. 201, pl. IV, fig. 7.

For the description of *L. macrurus* we must depend largely upon the elaborate description and figures of Nordqvist.

Forbes ('91, p. 706) thinks that our form is sufficiently different from the European to rank as a distinct variety. When preparing my former paper ('93) it did not seem to me that there was good reason for establishing a new variety. Recently I have made a more careful examination of the details of its structure, using material from Detroit River, Lake Michigan, and Green Lake. So far as the specimens I have examined are concerned, the points of difference mentioned by Forbes ('91, p. 707) do not exist. It seems to me that the twenty-fifth antennal segment is clearly separated from the twenty-fourth, and not consolidated as stated by him. In all my specimens I find the hook like spines on the eighth and twelfth segments.

Nordqvist and Forbes are in agreement in regard to the terminal teeth of the mandible, but Forbes finds one seta instead of the two figured by Nordqvist; in this respect my observations confirm those of Forbes. The accessory spines have been evident in my preparations. It would seem then, that unless *L. macrurus* is susceptible of local variations—a highly improbable supposition—that Forbes's variety can not stand, for the only point of difference on which it rests is the existence of one seta on the mandible instead of two.

The second joint of the second maxillipede differs slightly from Nordqvist's figure, and I have accordingly figured it. (Pl. V, fig. 5.) The difference appears to me, however, unimportant.

It is impossible to tell whether our species may not differ from the European in the armature of the antenna, as that was not worked out in detail by Nordqvist. In regard to the sensory setæ, he simply states that they are present on some of the segments, but does not state their number.

In the female, clavate sensory setæ are present on all joints except the 4th, 20th, 21st, 22d, and 24th. The setæ are distributed as follows: the first joint has three; there are two on the 2d, 3d, 5th, 7th, 9th, 10th, 11th 13th to 19th inclusive, and 22d to 24th inclusive; the 4th, 8th, 12th 20th, and 21st have one seta; the 6th has none; the 25th has four setæ, one of which is plumose; the 8th and 12th have, in addition to the ordinary and sensory setæ a hook-like spine.

The left antenna of the male is armed like the female antenna.

The right antenna of the male is 22-jointed, the 19-21 being united in one, and the 22d and 23d. The joint is between the 18th and 19th. The side of the 17th is produced into a blunt spine, and the 18th and 19th are armed on the inner margin with rows of minute spines. The number of the sensory setæ is the same as in the left antenna and in the antenna of the female, and not greater as stated by Nordqvist. In fact the differences in the armature of the right and left antennæ are only apparent, and are occasioned by the coalescence of the 19th–21st and the 22d and 23d joints.

It has seemed best to me to figure the swimming feet and describe them in some detail, in order to get a basis of comparison with similar forms.

In the first foot both the first and second basal joints are armed internally with a plumose seta. The first two joints of the exopodite have no external spines; the terminal joint has two external spines, two apical setæ—the outer spinulose on its outer margin—and three internal setæ. The terminal joint of the endopodite has one internal seta, two apical, and three internal.

The second, third and fourth feet have no seta on the second basal joint, and the first and second joints of the exopodite have each an external spine. In all the feet except the first there are groups of two or three minute spines at the bases of the spines of the exopodite.

The second and third feet are alike. The terminal joint of the exopodite has four internal setæ, and the terminal joint of the endopodite has two external setæ and four internal.

The fourth foot is like the second and third except that the terminal joint of the endopodite has three internal setæ. The fifth feet have no setæ on the basal joints. The second joint of the exopodite in the female is prolonged internally into a hook-like expansion. The exopodites of the male are two jointed, the terminal joints having a peculiar construction more easily understood from the figure than from any written description. The terminal joints of the endopodite in both male and female are armed with two external, two apical, and two internal setæ.

FAMILY CYCLOPIDÆ.—Genus CYCLOPS Müller.

KEY TO SPECIES OF CYCLOPS.

Antennæ 17-jointed,
  Fifth foot one-jointed, armed with one spine and two long setæ—a large species of dark color, ... *ater.*
  Fifth foot two-jointed,
    Second joint of fifth foot armed with seta and short spine,
      Terminal joint of outer branch of swimming feet armed externally with three spines,
        Furca of moderate length—occurring in pools, ... *Americanus.*
        Furca elongated, outer furcal seta abbreviated to a short, thick spine—limnetic in habit, ... *brevispinosus.*

Terminal joint of outer ramus of swimming feet armed externally with two spines,	*parcus.*
Second joint of fifth foot with two terminal setæ,	
Furca short—occurring in pools,	*navus.*
Furca elongated—limnetic in habit,	*pulchellus.*
Second joint of fifth foot with one terminal and one lateral seta,	*Leuckarti.*
Second joint of fifth foot with three setæ,	
With clavate seta on twelfth antennal segment, inner margin of furca not beset with hairs, egg-sacs lying away from abdomen,	*albidus.*
Sensory hair on twelfth antennal segment, inner margin of furca beset with hairs, egg-sacs close to abdomen,	*fuscus.*
Antennæ 16-jointed, fifth foot three-jointed,	*modestus.*
Antennæ 12-jointed, fifth foot one-jointed,	
Furca variable in length, armed externally with a row of fine spines,	*serrulatus.*
Furca short, without armature of spines—a small limnetic species,	*fluviatilis.*
Antennæ 11-jointed,	
Swimming feet 3-jointed,	*phaleratus.*
Swimming feet 2-jointed,	*bicolor.*
Antennæ 8-jointed,	*fimbriatus.*

CYCLOPS ATER Herrick.

Plate VI, figs. 1-4, 6, and 12.

1882. *C. ater* Herrick, p. 228, pl. III, figs. 9–12.
1884. " " " p. 145, pl. Q, figs. 9–12.
1887. " " " p. 14.

The cephalothorax is oval, nearly as broad as long, with the lateral angles produced caudally. The first segment equals two-thirds the total length of the cephalothorax.

The antennæ are 17-jointed, about as long as the cephalothorax, its segments having the typical armature of the *Cyclopidæ.* The last two segments have a smooth hyaline lamella, which in the last segment projects as a flat, blunt process beyond the end of the joint.

The abdomen is of moderate length, the last segment being armed posteriorly with a row of fine spines. The furca is rather more than twice as long as its width. The lateral spine is situated near the end. Of the terminal setæ, the outer is slightly shorter than the inner, the second is about twice as long as the outer, and the third about three times as long.

The swimming feet are armed as follows:

FIRST FOOT.

Outer br.	ex. 3 spines.	Inner br.	ex. 1 seta.
	ap. 2 setæ.		ap. 1 spine, 1 seta.
	in. 3 setæ.		in. 3 setæ.

SECOND AND THIRD FEET.

Outer br.	ex. 3 spines.	Inner br.	ex. 1 seta.
	ap. 1 spine, 1 seta.		ap. 1 spine, 1 seta.
	in. 4 setæ.		in. 3 setæ.

FOURTH FEET.

Outer br.	ex. 2 spines.	Inner br.	ex. 1 seta.
	ap. 1 spine, 1 seta.		ap. 2 spines.
	in. 4 setæ.		in. 2 setæ.

The fifth foot is one-jointed, and armed with a stout spine and two long setæ.

Average length 1. 77 mm.

A large, very robust form, of striking appearance because of its deep colors. The colors of the St. Clair specimens were as follows: antennæ, antennules, swimming feet and furcal setæ dark blue, almost black. The caudal margins of the cephalothorax have the same color. On each side of the abdomen, and extending to the ends of the furcæ is a strip of the same color but darker. Borders of the cephalothorax tinged with green. Oviducts white. The ovary is orange.

To the naked eye it resembles closely in form, size, and color an *Arrenurus* with which it is found associated. This may be a case of protective mimicry.

This species was originally described by Herrick in 1882, and is mentioned by him in his succeeding reports of 1884 and 1887, but has been noted by no other author. It was discovered by Professor Reighard in the St. Clair collections, and was worked out very thoroughly by him. It is from his notes that the above description is taken.

This seems to be a somewhat rare form in this region. I have found a few individuals in Rush Lake, Wisconsin, and in Michigan, besides in the St. Clair collections, have found it in Twenty-Sixth Lake, Intermediate Lake and Susan Lake. Where it occurs it is easily detected because of its large size and prominent colors. The specimens from Round Lake had more of the red color, so much so that this, on a superficial examination, seemed to be the most prominent color.

CYCLOPS BREVISPINOSUS Herrick.

Plate VII, fig. 12.

1884. *C. brevispinosus* Herrick, p. 148, pl. S, figs. 7–11.
1893. “ “ Marsh, p. 205, pl. IV, figs. 11 and 12.

C. brevispinosus occurred in the collections from Lake St. Clair, the Detroit river, Lake Erie, Susan Lake, Beaver Island, Intermediate Lake and Round Lake. I have found it in collections from Lake Superior and Lake Ontario, but, curiously, never in Lake Michigan collections.

Cyclops pulchellus Koch.

Plate VII, fig. 14.

1838. *C. pulchellus* Koch, H. 21, pl. 2.
1857. " *bicuspidatus* Claus, p. 209, pl. XI, figs. 6 and 7.
1863. " " " p. 101.
1863. " *pulchellus* Sars, p. 246.
1870. " *bicuspidatus* Heller, p. 71.
1872. " " Fric, p. 221, fig. 6.
1876. " " Hoek, p. 17, pl. I, figs. 7–11.
1880. " *pulchellus* Rehberg, p. 543.
1880. " *helgolandicus* Rehberg ('80a), p. 64, pl. IV, fig. 5.
1882. " *Thomasi* Forbes, p. 649, pl. IX, figs. 10, 11, and 16.
1883. " *pectinatus* Herrick, p. 499, pl. VII, figs. 25, 28.
1883. " *Thomasi* Cragin, p. 13, pl. III, figs. 1–13.
1884. " " Herrick, p. 151, pl. U, figs. 4, 5, 7, and 8.
1885. " *pulchellus* Daday, p. 220.
1886. " " Vosseler, p. 194, pl. V, figs. 19–28.
1890. " " Lande, p. 50, pl. XXI, figs. 146–155.
1891. " *Thomasi* Forbes, p. 707, pl. II, fig. 8.
1891. " *bicuspidatus* Brady, p. 13, pl. V, figs 1–5.
1891. " *Thomasi* Brady, p. 14, pl. VI, figs. 1–4.
1891. " *bicuspidatus* Schmeil, p. 27.
1891. " " Richard, p. 229, pl. VI, fig. 6.
1892. " " Schmeil, p. 75, pl. II, figs. 1–3.
1893. " *Thomasi* Forbes, p. 249, pl. XXXIX, figs. 9–12, pl. XL, fig. 13.
1893. " *pulchellus* Marsh, p. 207, pl. IV, figs. 18–19.

C. pulchellus is the common *Cyclops* of the Great Lakes. It occurs sometimes in smaller bodies of water, but in the collections from Michigan I have not found it from any of the small lakes except Pine Lake and Round Lake.

According to Forbes ('82 b) *C. pulchellus* and the *Diaptomi* form the greater part of the food of the young white fish.

Cyclops parcus Herrick.

1882. *C. parcus* Herrick, p. 229, pl. VI, figs. 12–15.
1884. " " ' p. 148, pl. R, fig. 22.
1893. " " Marsh, p. 208, pl. IV, fig. 16, pl. V, fig. 1.

I have found *C. parcus* only in the collections from Lake St. Clair.

Cyclops leuckarti Sars.

Plate VII, fig. 15.

1863. *C. Leuckarti* Sars, p. 239.
1874. " *simplex* Poggenpol, p. 70, pl. XV, figs. 1–3.
1875. " *tenuicornis* Uljanin, p. 30, pl. IX, figs. 12 and 13.
1876. " *Leeuwenhockii* Hoek, p. 19, pl. III, figs. 1–12.
1880. " *simplex* Rehberg, p. 542.
1884. " " Herrick, p. 150.

1884. *C. oithonoides* Herrick, p. 150, pl. S, figs. 2–6.
1885. “ *Leuckarti* Daday, p. 218.
1885. “ *simplex* Daday, p. 236.
1885. “ *pectinatus* Daday, p. 223, pl. I, figs. 7–13.
1886. “ *simplex* Vosseler, p. 193, pl. IV, figs. 15–17.
1887. “ “ Herrick, p. 17, pl. VII, fig. 1, a-j.
1890. “ “ Thallwitz, p. 79.
1890. “ “ Lande, p. 55, pl. XVI, figs. 42–45; pl. XVII, figs. 46–50.
1891. “ *Leuckarti* Schmeil, p. 25.
1891. “ *edax* Forbes, p. 709, pl. III, fig. 15; pl. IV, figs. 16–19.
1891. “ *Scourfeldi* Brady (?) p. 10, pl. IV, figs. 1–8.
1891. “ *Leuckarti* Richard, p. 230, pl. VI, fig. 20.
1892. “ “ Schmeil, p. 57, pl. III. figs. 1–8.
1893. “ “ Marsh, p. 209, pl. IV, fig. 17; pl. V, figs. 2–6.

I have no doubt that, as stated by Schmeil, *C. Leuckarti* Claus and *C. Leuckarti* Sars are identical, and that possibly by strict laws of priority Claus should be given as authority for the name. Yet, as the description by Claus is not only imperfect, but in many respects inaccurate and misleading, I have preferred to retain the designation of *C. Leuckarti* Sars. Other points in the synonomy are discussed in Schmeil '92 and Marsh '93.

As would be expected, this species was distributed almost universally in the waters examined.

CYCLOPS FUSCUS Jurine.

Plate VI, figs. 5, 7 and 11.

1820. *Monoculus quadricornis fuscus* Jurine, p. 47, pl. II, fig. 2.
1841. *C. signatus* Koch, H 21, pl. VIII.
1850. “ *quadricornis var. c* Baird, p. 203, pl. XXIV, fig. 5.
1857. “ *coronatus* Claus, p. 29, pl. I, fig. 5, and pl. II, figs. 1–11.
1863. “ “ “ p. 97, pl. II, fig. 16; pl. X, fig. 1.
1863. “ *signatus* Sars, p. 242.
1863. “ *coronatus* Lubbock, p. 199.
1870. “ “ Heller, p. 71.
1872. “ “ Fric, p. 218, fig. 12.
1876. “ “ Hoek, p. 12.
1878. “ *signatus* Brady, p. 100, pl. XVII, figs. 4–12.
1882. “ *tenuicornis* Herrick, p. 227, pl. V, fig. 14; pl. VI, figs. 1–11, and 20.
1884. “ *tenuicornis* Herrick, p. 153, pl. R, fig. 16; pl. Q^4, figs. 8–11, and 20.
1885. “ *signatus* Daday, p. 208.
1886. “ “ Vosseler, p. 189, pl. IV, figs. 6–10.
1888. “ *fuscus* Sostariç, p. 58.
1890. “ *signatus* Thallwitz, p. 79.
1890. “ “ Lande, p. 33, pl. XV, figs. 1–12.
1891. “ “ Brady, p. 6, pl. 2, fig. 5.
1891. “ *fuscus* Richard, p. 223, pl. VI, fig. 6.
1891. “ “ Schmeil, p. 22.
1892. “ “ “ p. 123, pl. I, figs. 1–7b; pl. IV, fig. 2.
1893. “ *signatus* Marsh, p. 211.

In my paper on the Wisconsin *Cyclopidæ* and *Calanidæ* ('93), agreeing with Herrick and Brady, I expressed my belief that the two forms here called *fuscus* and *albidus*, the *coronatus* and *tenuicornis* of Claus, belonged to the same species, *fuscus* being the more mature form. Since writing that paper I have examined a large number of specimens from widely separated localities, and I must acknowledge that I was wrong, and that, as stated by Schmeil ('92), the two forms must be considered distinct, for I have been utterly unable to find the connecting forms. The points of difference, as stated so elaborately by Schmeil, hold good for the American specimens. *C. fuscus* has a sensory hair on the twelfth antennal segment, the hyaline lamella of the 17th segment deeply notched, the third segment of the antennule short, the inner borders of the furca thickly beset with hairs, and the egg sacs lie close to the abdomen, while *C. albidus* has a clavate seta on the twelfth antennal segment, the membrane of the 17th segment serrate or smooth, the inner borders of the furca either without hairs or with only fine hairs, and the egg sacs lie separated from the abdomen. These characters, with the greater size of *C. fuscus*, serve to distinguish the species, while the less evident characters mentioned by Schmeil are easily demonstrated.

One characteristic not mentioned by Schmeil I have found constantly in my specimens. The larger of the two terminal spines of the endopodite of the fourth foot, instead of being serrated on its edges as is customary in all the spines of the swimming feet, is beset on its inner margin with long, rather irregular teeth, as shown in the plate. (Plate VI, fig. 7.) If this peculiarity exists in the European forms, it would seem probable that it would have been noted by some observer, but I have nowhere seen an account of it. It may serve then to indicate a slight variation from the European type.

I have found *C. fuscus* in the Michigan collections from only one locality, Intermediate Lake. I have found it in several Wisconsin localities, though nowhere abundantly, and it is probable that it occurs in other localities in Michigan.

CYCLOPS ALBIDUS Jurine.

Plate VI, figs. 8–10.

1820. *Monoculus quadricornis albidus* Jurine, pp. 44 and 47, pl. II, figs. 10 and 11; pl. III, fig. 24.
1841. *C. annulicornis* Koch, H 21, pl. VI.
1850. " *quadricornis* var. *b* Baird, p. 202, pl. XXIV, fig. 4.
1857. " *tenuicornis* Claus, p. 31, pl. III, figs. 1–11.
1857. " *pennatus* Claus, p. 35, pl. III, figs. 12–17.
1863. " *tenuicornis* Claus, p. 99, pl. I, fig. 3; pl. II, fig. 17; pl. IV, fig. 5.
1863. " *tenuicornis* Sars, p. 242.
1863. " *annulicornis* Sars, p. 243.
1863. " *tenuicornis* Lubbock, p. 202.
1870. " *tenuicornis* Heller, p. 71.
1872. " " Fric, p. 219, fig. 12.
1874. " *Clausii* Poggenpol, p. 70, pl. XV, figs. 4–14.
1875. " *signatus* Uljanin, p. 29, pl. IX, figs. 6–11; pl XI, fig. 8.
1876. " " Hoek, p. 12, pl. I, figs. 1–4.

1878. *C. tenuicornis* Brady, p. 102, pl. XVII, figs. 1–10.
1882. “ “ Herrick.
1883. “ “ Cragin, p. 3, pl. II, figs. 1–14.
1883. “ *signatus* var. *fasciacornis* Cragin, p. 2, pl. II, fig. 15.
1884. “ *tenuicornis* var. *a* Herrick, p. 153, pl. Q^4, figs. 1–7.
1885. “ “ Daday, p. 211.
1886. “ “ Vosseler, p. 189, pl. IV, figs. 6–10.
1888. “ *albidus* Sostariç, pl. I, figs. 3, 4 and 12.
1890. “ *tenuicornis* Thallwitz, p. 79.
1890. “ “ Lande, p. 36, pl. XVI, figs. 22–32.
1891. “ *gyrinus* Forbes, p. 707, pl. II, fig. 9; pl. III, fig. 14.
1891. “ *albidus* Schmeil, p. 23.
1891. “ *annulicornis* and *tenuicornis* Richard, pp. 224–226.
1892. “ *albidus* Schmeil, p. 128, pl. I, figs. 8–14b; pl. IV, fig. 2.
1893. “ *signatus* Marsh, p. 211, pl. V, figs. 7–9.

Schmeil states that the antennæ of *C. albidus* are armed with crowns of spines as in the case of *C. fuscus*. This seems to be rarely true in our forms. Although I have examined with great care large numbers of mature females, it is only in very few specimens that I have found this peculiar armature. The membrane of the terminal antennal segment is ordinarily serrate. The common form corresponds to the *annulicornis* of Sars and Richard, which, according to Schmeil, Richard now allows to be a variety of *albidus*. The distinguishing characteristic of *annulicornis* is the rudimentary seta of the inner margin of the terminal segment of the endopodite of the fourth foot. This is represented in most of my specimens only by a minute spine. (Pl. VI, fig. 9.) In two individuals I have found in place of this minute spine a short seta. (Pl. VI, fig. 8.) In these two specimens the circlets of spines were present on the 8th, 9th, 10th, 12th, 13th, and 14th segments. It was this form evidently that Cragin called *C. tenuicornis* ('83 pl. II, figs. 1–14), as is shown very clearly by the figures of the fourth foot and antennule, although he did not figure the circlets of spines on the antennal segments. *C. signatus* var. *fasciacornis* Cragin, it is not possible to identify with certainty, although it seems probable that it is *albidus*. *C. gyrinus* Forbes does not have the antennal circlets of spines, but does have a short seta instead of a minute spine on the fourth foot, thus agreeing with Cragin's figures of *C. tenuicornis*. This would seem to be intermediate between the two forms I have seen. It is difficult in such a case to tell just where the limits of species should be drawn, for we are entirely ignorant of the life histories of the forms, and it is certain that the *Cyclopidæ* have wide limits of variation. It seems to me safer, for the present, at least, to consider such minute differences as varietal, and not to increase the number of species.

C. albidus is not very abundant, but occurred in many of the St. Clair collections, and in some of those from other points in Michigan. It is a universally distributed species, but does not occur in great numbers.

Cyclops fluviatilis Herrick.

1882. *C. fluviatilis* Herrick, p. 231, pl. VII, figs. 1–9.
1883. “ *magnoctavus* Cragin, p. 5, pl. II, figs 14–23.
1884. “ *fluviatilis* Herrick, p. 159, pl. Q^5, figs. 1–9.
1887. “ “ Herrick, p. 15.

1891. *C. magnoctavus* Brady, p. 19, figs. 1–4.
1893. " *fluviatilis* Marsh, p. 214, pl. V, figs. 14 and 15; pl. VI, fig. 1.

C. fluviatilis occurs in most of the limnetic collections in all except the smallest bodies of water.

CYCLOPS SERRULATUS Fischer.

1851. *C. serrulatus* Fischer, p. 423, pl. X, figs. 22, 23, 26–31.
1853. " " Lilljeborg, p. 158, pl. XV, fig. 12.
1857. " " Claus, p. 36, figs. 1–3.
1863. " " Sars, p. 254.
1863. " " Claus, p. 101, pl. I, figs. 1 and 2; pl. IV, fig. 12; pl. XI, fig. 3.
1863. " " Lubbock, p. 197.
1870. " " Heller, p. 72.
1872. " " Fric, p. 222, fig. 18.
1875. " " Uljanin, p. 34, pl. VIII, figs. 1–8.
1878. " " Brady, p. 109, pl. XXII, figs. 1–6.
1878. " " var. *montanus* Brady, p. 110, pl, XXII, figs. 7–14.
1880. " *agilis* Rehberg, p. 545.
1882. " " Forbes, p. 649.
1882. " *serrulatus* Herrick, p. 230, pl. V, figs. 1–5; pl. VII, fig. 10.
1883. " *pectinifer* Cragin, p. 6, pl. IV, figs. 1–7.
1884. " *serrulatus* Herrick, p. 157, pl. O, figs. 17–19.
1884. " " var. *elegans* Herrick, p. 158.
1885. " *agilis* Daday, p. 240.
1886. " " Vosseler, p. 190, pl. V, figs. 29–31.
1890. " " Thallwitz, p. 79.
1890. " " Lande, p. 60, pl. XVII, fig. 69; pl. XVIII, figs. 70–80.
1891. " *serrulatus* Schmeil, p. 29.
1891. " " Richard, p. 234, pl. VI, figs. 6–12.
1891. " *agilis* Forbes, p. 710.
1892. " *serrulatus* Schmeil, p. 141, pl. V, figs. 6–12.
1893. " " Marsh, p. 215, pl. VI, figs. 2–5.

This well known species occurs everywhere in Michigan waters and with the same variations in structure which I have noted in the collections made in Wisconsin. (Marsh '93, pp. 215–216.)

CYCLOPS PHALERATUS Koch.

1838. *C. phaleratus* Koch, H 21, pl. IX.
1851. " *canthocarpoides* Fischer, p. 426, pl. X, figs. 24, 25, 32–38.
1853. " " Lilljeborg, p. 208.
1857. " " Claus, p. 37, pl. I, figs. 6–10.
1863. " " " p. 102, pl. IV, figs. 1–4.
1863. " " Lubbock, p. 202.
1863. " *phaleratus* Sars, p. 255.
1872. " *canthocarpoides* Fric, p. 223, fig. 19.
1874. " *lascivus* Poggenpol, p. 72, pl. XV. figs. 22–24; pl. XVI, figs. 7 and 8.
1875. " *phaleratus* Uljanin, p. 38, pl. IX, figs. 1–5.
1878. " " Brady, p. 116, pl. XXIII, figs. 7–13.
1882. " *adolescens* Herrick, p. 231, pl. VI, figs. 15–20.

1883. *C. perarmatus* Cragin, p. 7, pl. I, figs. 9–18.
1884. " *phaleratus* Herrick, p. 161, pl. R, figs. 6–10.
1885. " " Daday, p. 252.
1887. " " Herrick, p. 14, pl. VII, figs. 2, a–d.
1888. " " Sostariç, p. 74, pl. II, figs. 21–22.
1890. " " Lande, p. 75. pl. XX, figs. 126–136.
1891. " " Schmeil, p. 36.
1891. " " Brady, p. 25, pl. IX, fig. 2.
1891. " " Richard, p. 238, pl. VI, fig. 12.
1892. " " Schmeil, p. 170, pl. VIII, figs. 1–11.
1893. " " Marsh, p. 216, pl. VI. figs. 6 and 7.

I have found *C. phaleratus* in the collections from only three localities,—Lake St. Clair, Intermediate Lake, and Twenty-sixth Lake. Very little attention, however, was paid in the collections to the smaller lakes and stagnant pools, and it is probable that in such localities it occurs generally distributed through the State.

Cyclops bicolor Sars.

Plate I, figs. 5–7.

1863. *C. bicolor* Sars, p. 253.
1880. " *diaphanus* Rehberg, p. 547.
1884. " " Herrick, p. 160, pl. R, fig. 12.
1885. " " Daday, p. 246.
1885. " *brevisetosus* Daday, p. 255, pl. III, figs. 3, 5 and 10.
1887. " *diaphanus* Herrick, p. 16, pl. VII, figs. 3 a–e.
1888. " " Lande. p. 67, pl. 18, figs. 91–98.
1891. " *bicolor* Schmeil, p. 34.
1891. " *diaphanus* Richard, p. 236, pl. VI, fig. 26.
1892. " *bicolor* Schmeil, p. 118, pl. VI, figs. 6–13.
1893. " " Marsh, p. 217.

I have found *C. bicolor* in the collections from three of the Michigan lakes—Lake St. Clair, Intermediate Lake, and South Lake on Beaver Island. Doubtless more thorough collections from small lakes and stagnant pools would furnish other localities, though this species seems to be nowhere very abundant. I have found, in a collection from a lake in northern Wisconsin, an egg-bearing female with ten-jointed antennæ, the fourth and fifth joints of the eleven-jointed variety being united in one. Unless this specimen should be considered a monstrosity, we would infer that this species can reproduce in either the ten or eleven-jointed stage.

I have added to the synonomy as previously given *C. brevisetosus* Daday. I do not feel certain of the identity of the two forms, and yet it seems to me probable that they are the same. I can not read the Hungarian, but from the Latin synopsis and the figures I can not help thinking that *brevisetosus* is the same as *bicolor*. The points of difference are the following. The furca of *brevisetosus* is longer than in typical *bicolor*. The armature of the swimming feet does not correspond to Daday's description, but the one figure which he gives of a swimming foot closely resembles the structure of *bicolor*, and does not correspond to his own description. The antennæ of *brevisetosus* are ten-jointed, but they correspond exactly to the structure of my ten-jointed specimen of *bicolor*. In all other respects the descriptions agree.

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Although the list of papers consulted is very nearly the same as that of my paper on the Wisconsin *Cyclopidæ* and *Calanidæ*, I have though it best to insert it in this paper for convenience of reference. I have not had the opportunity of seeing the original paper of Poggenpol, nor the papers of Sostariç and Thallwitz, and the quotations from those authors are taken from Schmeil. In all other cases I have personally verified the references.

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EXPLANATION OF PLATES.

PLATE I.

Fig. 1. *Diaptomus Reighardi*—fifth feet of female x 340.
2. “ “ abdomen of male x 195.
3. “ “ fifth feet of male x 223.
4. “ “ abdomen of female x 190.
5. *Cyclops bicolor*—abdomen of female x 269.
6. “ “ antenna of female x 333.
7. “ “ 10-jointed antenna of female x 325.

PLATE II.

Fig. 1. *Epischura lacustris*—antenna of female x 113.
2. “ “ right antenna of male x 113.
3. “ “ antennule x 113a.
4. “ “ mandible and palpus x 217.
5. “ “ second maxillipede x 217.
6. “ “ first maxillipede x 217.

PLATE III.

Fig. 1. *Epischura lacustris*—first foot x 217.
2. “ “ second foot x 153.
3. “ “ fifth foot of female x 217.
4. “ “ fifth foot of male x 153.
5. “ “ abdomen of female x 113.
6. “ “ abdomen of male x 113.

PLATE IV.

Fig. 1. *L. macrurus*—right antenna of male x 275.
2. “ “ left antenna of male x 275.

PLATE V.

Fig. 1. *L. macrurus*—first foot x 275.
2. “ “ second foot x 275.
3. “ “ fifth foot of female x 275.
4. “ “ fifth foot of male x 275.
5. “ “ second and third joints of second maxillipede x 275.

PLATE VI.

Fig. 1. *Cyclops ater*—abdomen of male x 146.
2. “ “ receptaculum seminis x 113.
3. “ “ fourth foot x 113.
4. “ “ 11th, 12th, and 13th antennal segments of female x 113.
5. “ *fuscus*—terminal joints of female antenna x 217.
6. “ *ater*—terminal joints of female antenna x 217.
7. “ *fuscus*—terminal joint of endopodite of fourth foot x 217.
8. “ *albidus*—terminal joint of endopodite of fourth foot x 280.
9. “ “ terminal joint of endopodite of fourth foot x 280.
10. “ “ antennule x 217.
11. “ *fuscus*—antennule, first three joints x 217.
12. “ *ater*—outline of cephalothorax of female x 108.

PLATE VII.

Fig. 1. *Diaptomus sicilis*—fifth feet of male x 140.
2. “ *Ashlandi*—fifth feet of male x 140.
3. “ *minutus*—fifth feet of male x 140.
4. “ “ fifth foot of female x 250.
5. “ *oregonensis*—fifth feet of male x 140.
6. “ *pallidus*—fifth feet of male x 200.
7. “ *leptopus*—fifth feet of male x 138.
8. “ *sanguineus*—fifth feet of male x 138.
9. “ *Birgei*—fifth feet of male x 136.
10. “ *sanguineus*—terminal joints of male antenna x 136.
11. “ *sicilis*—terminal joints of male antenna x 136.
12. *Cyclops brevispinosus*—fifth foot x 250.
13. “ *modestus*—fifth foot x 250.
14. “ *pulchellus*—fifth foot x 250.
15. “ *Leuckarti*—fifth foot x 250.

PLATE VIII.

Sketch map of Lake St. Clair and vicinity, showing collecting stations.

PLATE IX.

Sketch map of Charlevoix and vicinity showing collecting stations.

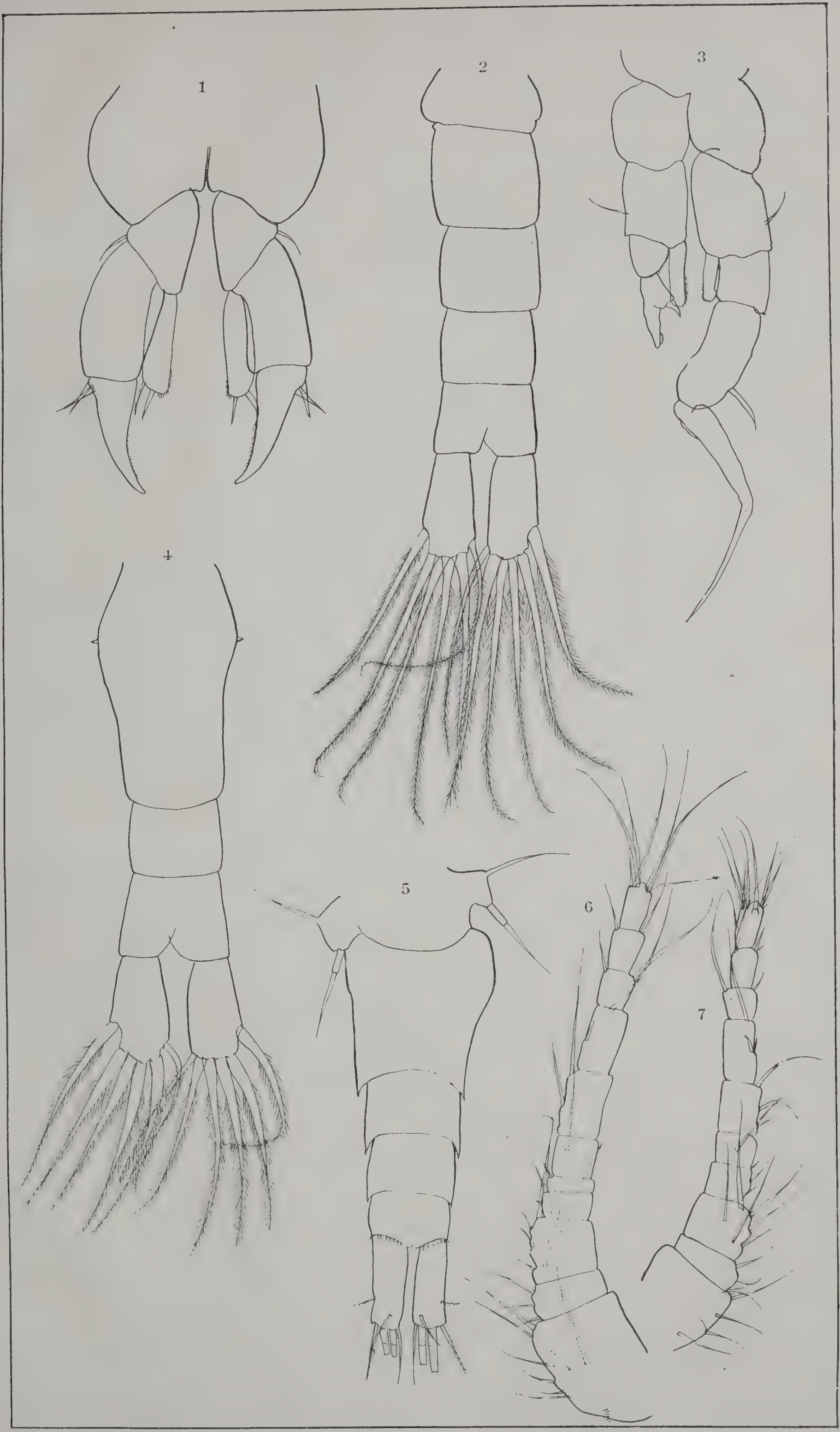
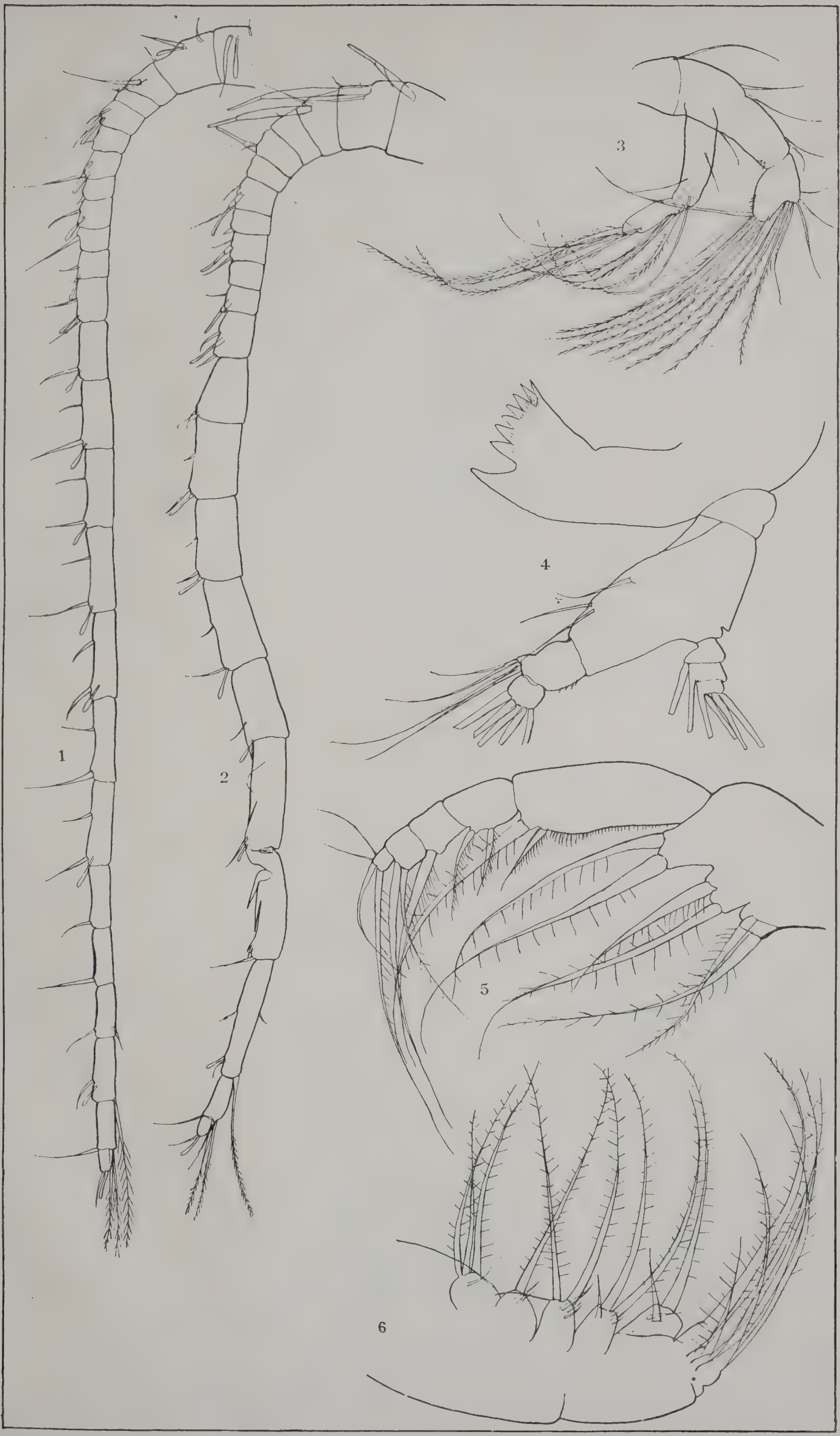


PLATE I.



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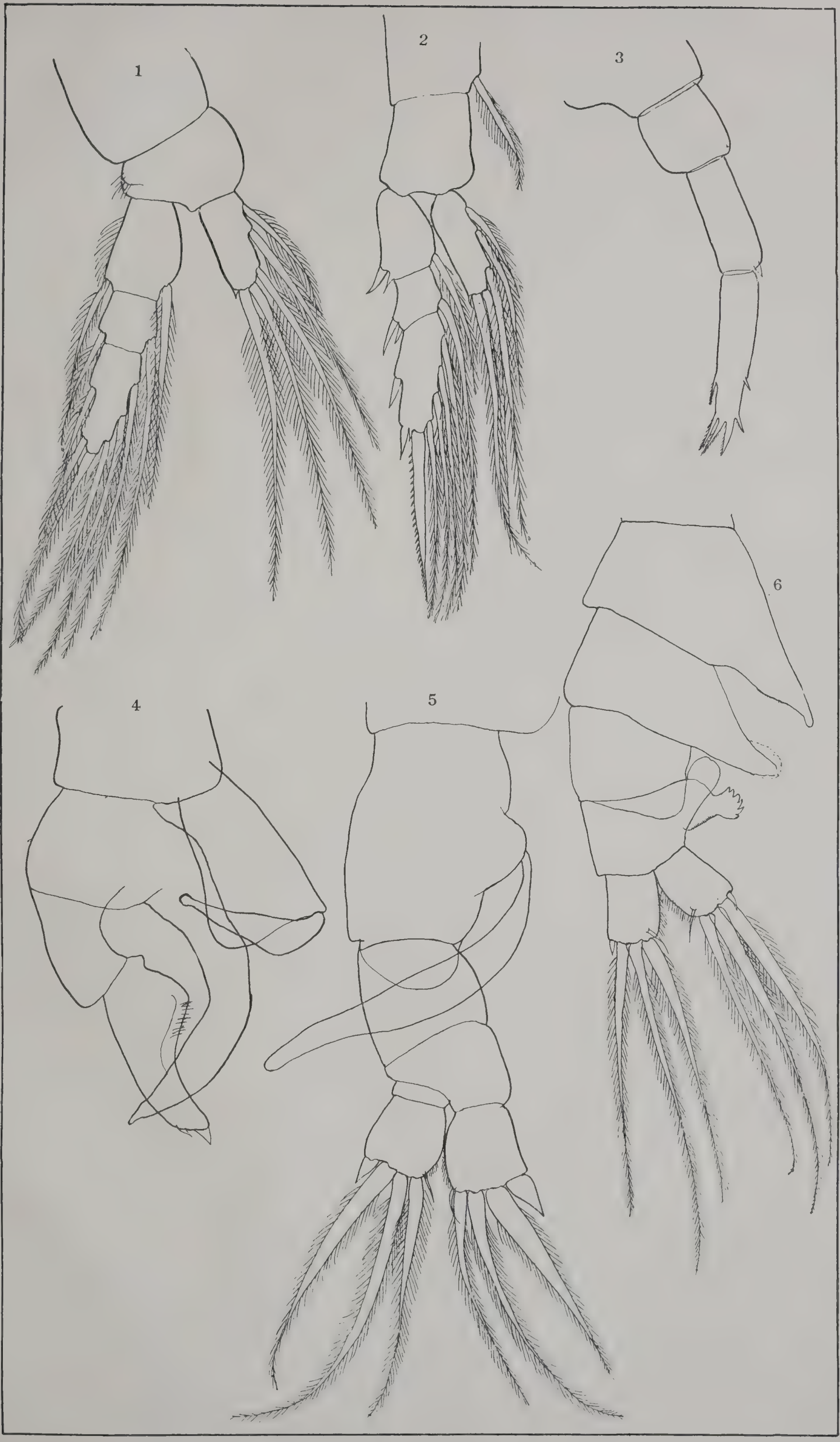

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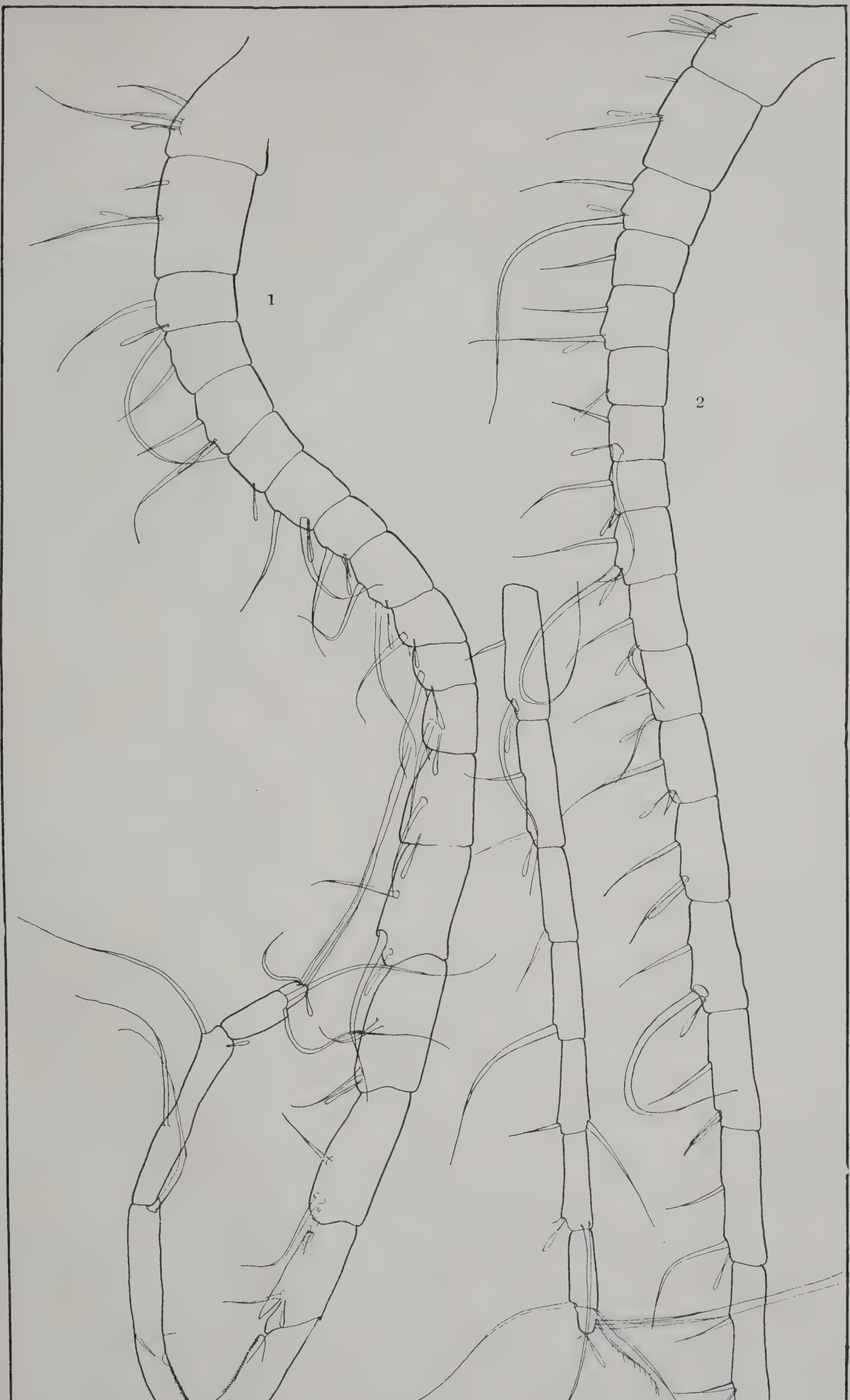

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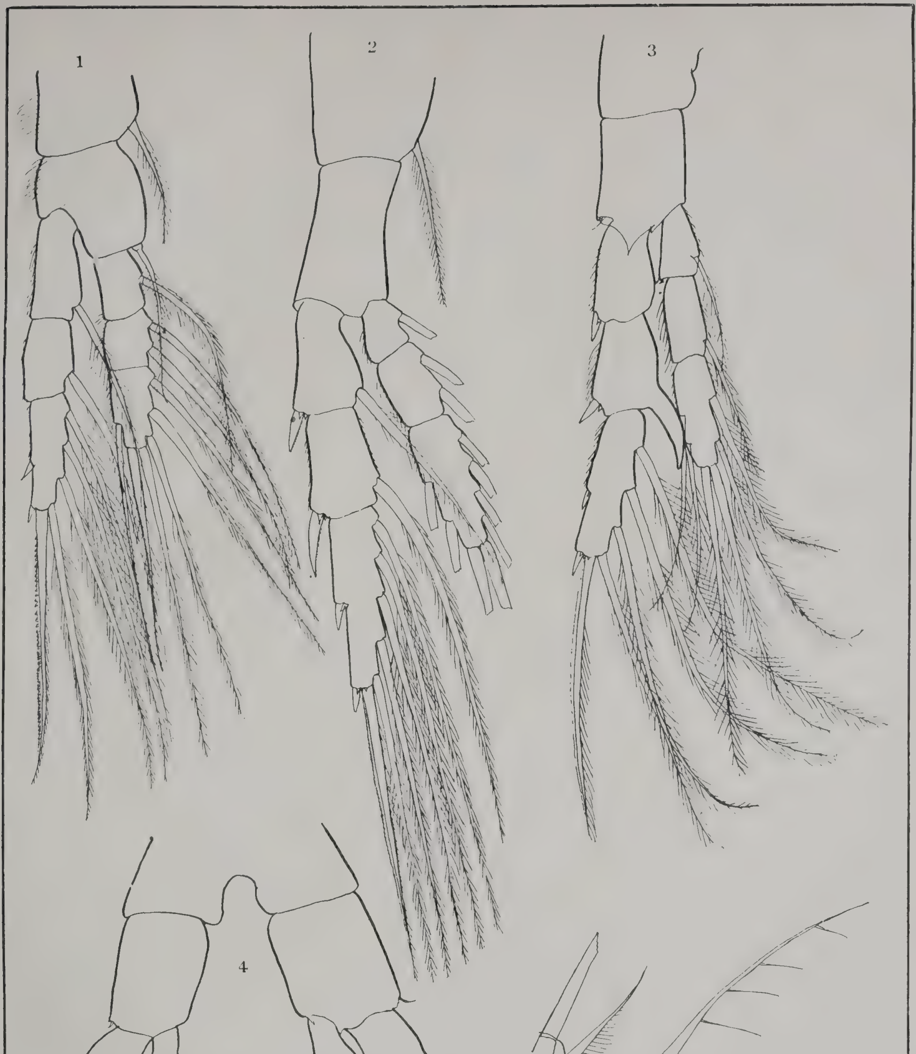

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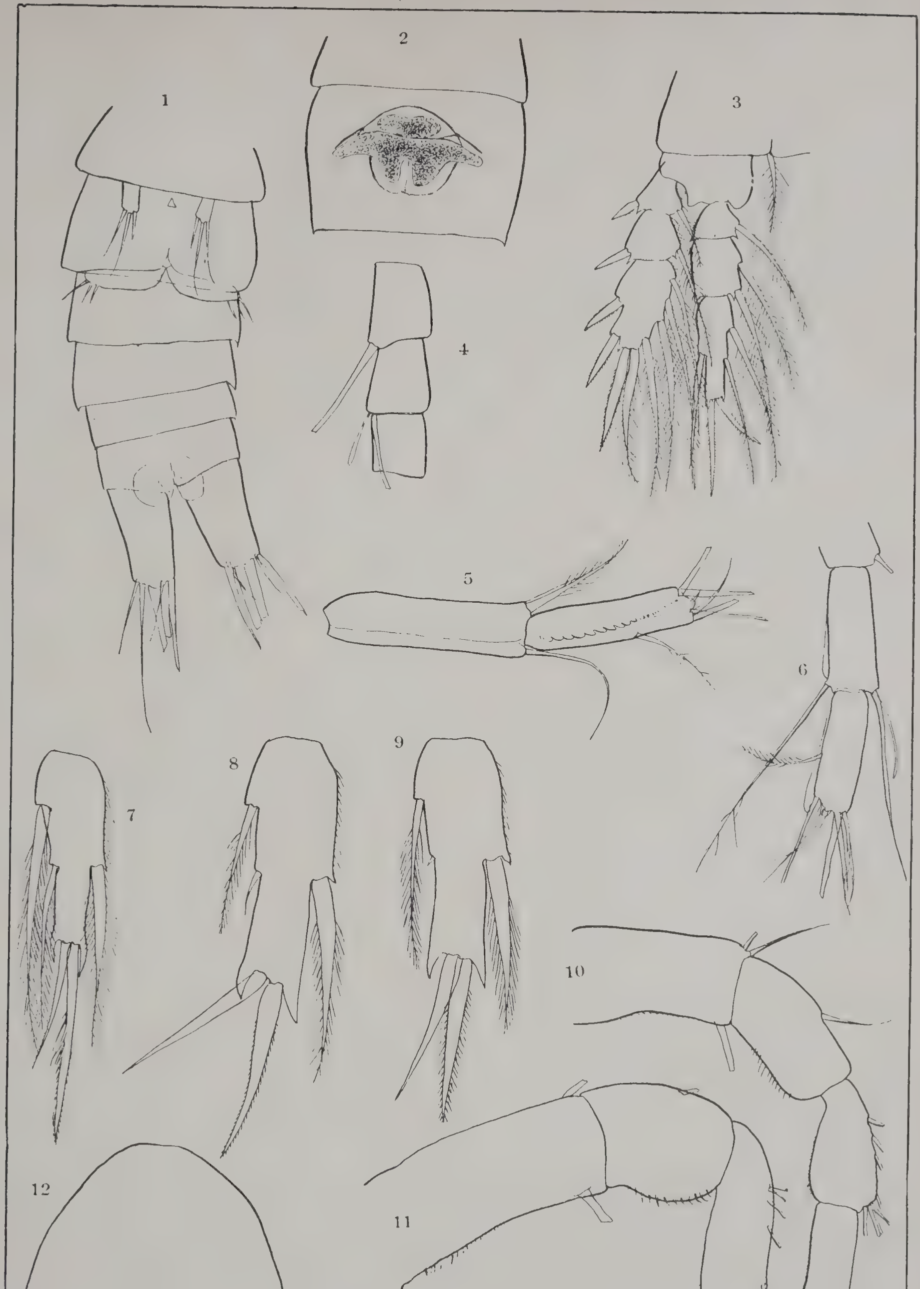

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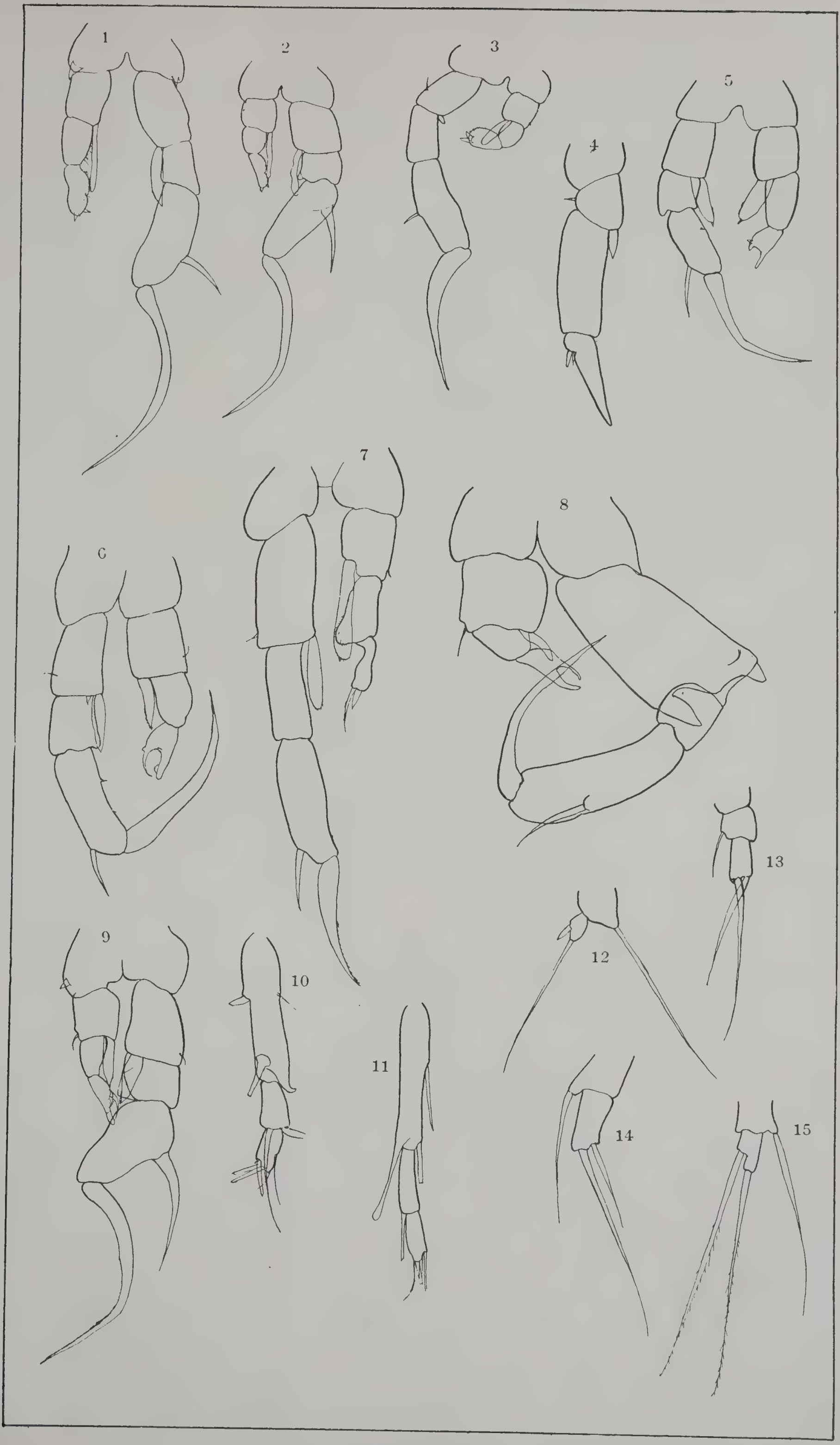

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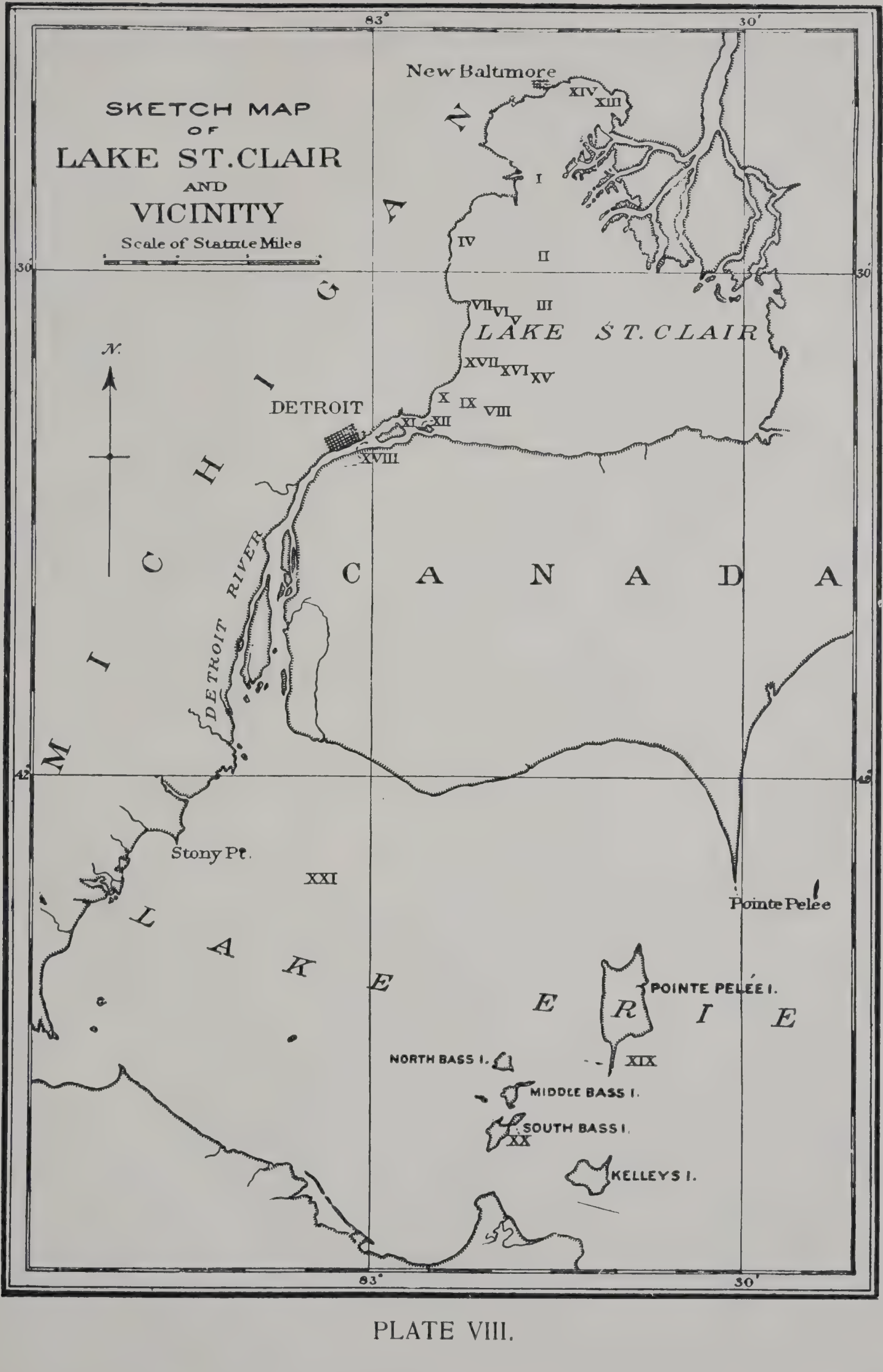

SKETCH MAP
OF
LAKE ST. CLAIR
AND
VICINITY
Scale of Statute Miles
83°
30′
30′
42°
N.
New Baltimore
LAKE ST. CLAIR
DETROIT
DETROIT RIVER
MICHIGAN
CANADA
Stony Pt.
Pointe Pelee
LAKE ERIE
POINTE PELÉE I.
NORTH BASS I.
MIDDLE BASS I.
SOUTH BASS I.
KELLEYS I.
I
II
III
IV
V
VI
VII
VIII
IX
X
XI
XII
XIII
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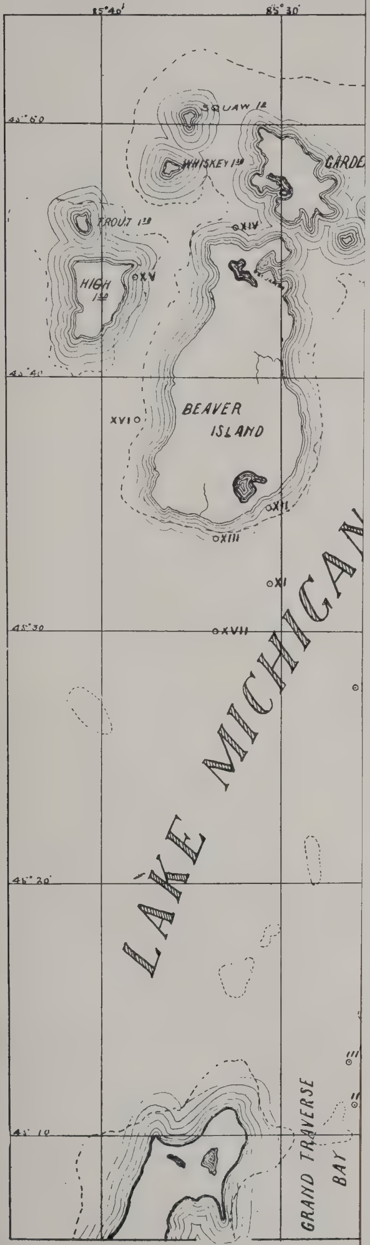
XV
XVI
XVII
XVIII
XIX
XX
XXI

PLATE VIII.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85°30'
45°50'
SQUAW Id
WHISKEY Id
GARDE
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XIV
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XV
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BEAVER ISLAND
XVI
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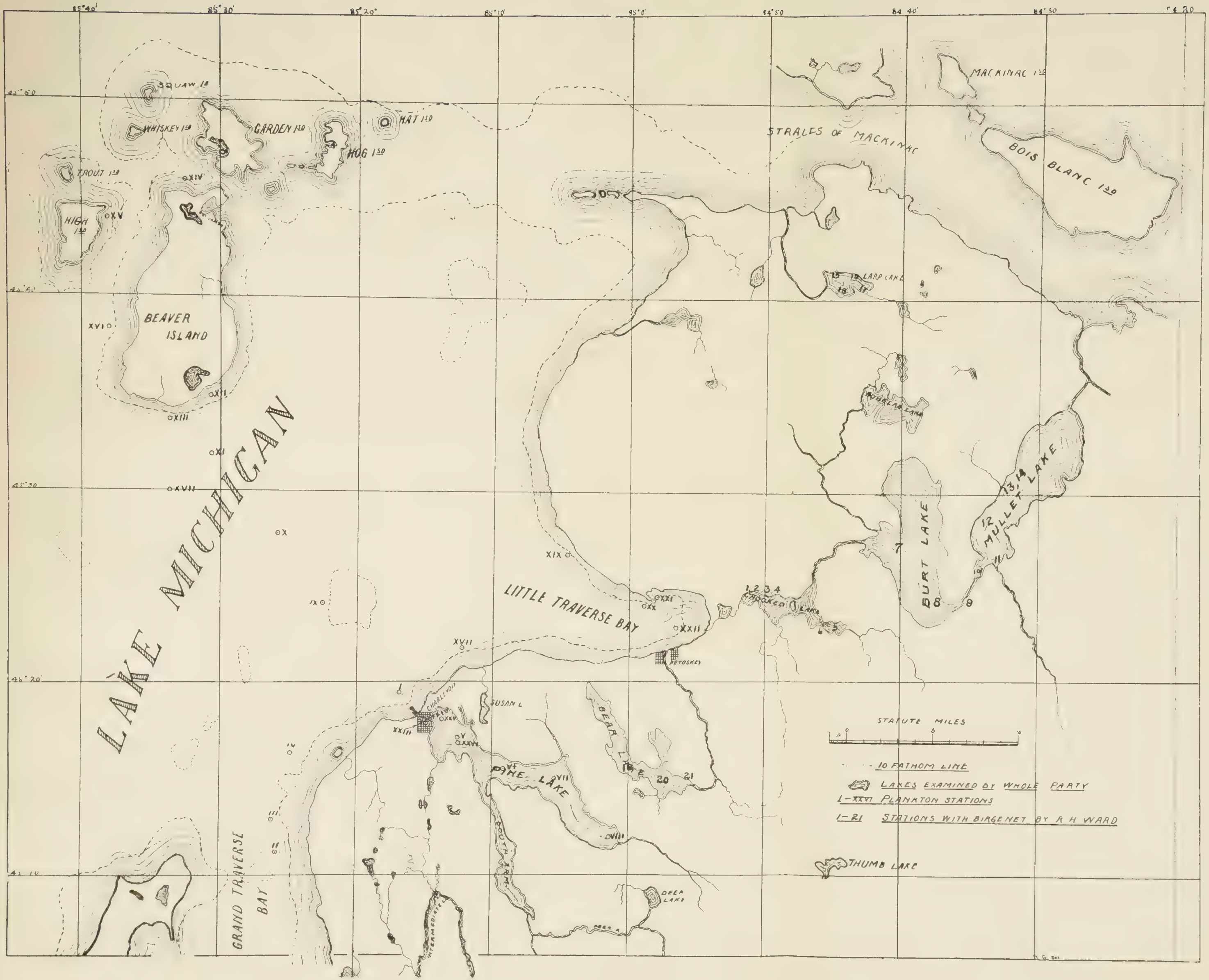
XI
45°30'
XVII
LAKE MICHIGAN
45°20'
III
II
45°10'
GRAND TRAVERSE BAY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SQUAW I^d
WHISKEY I^d
GARDEN I^d
HAT I^d
HOG I^d
TROUT I^d
HIGH I^d
BEAVER ISLAND
MACKINAC I^d
STRAITS OF MACKINAC
BOIS BLANC I^d
CARP LAKE
DOUGLAS LAKE
BURT LAKE
MULLET LAKE
CROOKED LAKE
LAKE MICHIGAN
LITTLE TRAVERSE BAY
PETOSKEY
CHARLEVOIX
SUSAN L
BEAR LAKE
PINE LAKE
SOUTH ARM
INTERMEDIATE L
DEER LAKE
DEER R
GRAND TRAVERSE BAY
THUMB LAKE
STATUTE MILES
0
5
10
10 FATHOM LINE
LAKES EXAMINED BY WHOLE PARTY
I–XXVI PLANKTON STATIONS
1–21 STATIONS WITH BIRGE NET BY R H WARD

PLATE IX.

Bulletin of the Michigan Fish Commission

No. 6

A BIOLOGICAL EXAMINATION OF LAKE MICHIGAN

IN THE

TRAVERSE BAY REGION

By Henry B. Ward

WITH THE FOLLOWING APPENDICES

I.	The Aquatic Plants	By H. D. Thompson
II.	The Protozoa	By C. A. Kofoid
III.	The Rotifera	By H. S. Jennings
IV.	The Turbellaria	By W. McM. Woodworth
V.	The Mollusca	By Bryant Walker

LANSING
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1896

INTRODUCTION.

During the summer of 1893 the Michigan Fish Commission entered upon a biological study of the Great Lakes by maintaining a party on Lake St. Clair. In the report of that two months, written by the director of the laboratory, Professor J. E. Reighard, are given in full the reasons which led to the inception of the undertaking and the aims which its promoters held in view. A study of the life of the lake in all its manifold interrelations and especially of those factors which bore upon the welfare of the food fishes in general and the young whitefish in particular were the ends sought. On the attainment of these ends depends the determining of those conditions most favorable for the fry, and hence the character of the places in which they should be planted. Those who may doubt the propriety of such undertakings as this will find in the report just cited (Reighard, 95*, p. 1–5) an extended and convincing discussion of the question in its various bearings.

Ever since its establishment by legislative enactment, which named specifically "the cultivation of the whitefish" among its duties, the Michigan Fish Commission has been active in effort in behalf of this important and diminishing food supply. The work of the first year of lake investigation on Lake St. Clair had been carried on in the waters of a great spawning ground of the whitefish, and it seemed wise in the second year to transfer operations to a locality which was the home of this species throughout the entire year, and which afforded hence an opportunity of studying it continuously in its natural environment. The absence of Professor Reighard in Europe prevented his taking charge of the work, and the writer, who had been his assistant during the previous summer, was asked to assume control. The opportunity was all the more readily accepted since it was joined with the express desire on the side of the Commission that the general aims of the past be kept in view and that the whitefish be made the object of especial study for the purpose of ascertaining definitely the character of its food and the life of the young which had been hitherto an absolutely unknown quantity.

The exact location of the laboratory was a matter of great importance, and in company with the superintendent of the Commission, Mr. S. Bower, I visited the Traverse Bay region. Charlevoix seemed the most available location and was selected finally by the Board of Commissioners as a center for the summer's work. A shop on the shore of Round Lake was rented and fitted up as a laboratory. An adjacent building, in which was located a small hatchery of the Commission, furnished abundant conveniences in the way of aquaria, and running water for the permanent accommodation of fish and larger forms. In this building, which was located on a fine dock, were kept the nets, dredges, trawl and other large apparatus. The laboratory proper was well equipped with tables for microscopic work and shelves for books, glassware and other necessities. A couple of tables in the center of the room held small glass aquaria and a zinc topped table near the south side afforded an opportunity for such work as required running water. Immediately north of the laboratory was a small dock from which pure water could be dipped out of Round Lake, and where in fact on more than one occasion various young fry were landed with a simple dip net. (See Pl. IV.)

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* References to the papers cited at the close of the report are indicated in this way.

The laboratory was well equipped with glassware, reagents, etc., by the Fish Commission, and the various forms of collecting apparatus were also provided by them. Most of this was the same as that used the previous year and was sufficiently described in Professor Reighard's report. In addition there was used a small trawl of six feet beam and a new form of towing net for surface work, known as the "torpedo." The trawl was of the ordinary type and the torpedo net is described elsewhere in this report. A rake dredge of the type ordinarily employed in marine work was made for our use and proved highly satisfactory in many localities. To the University of Michigan the party was indebted for the loan of numerous microscopes and accessories, various laboratory apparatus and finally an extensive library of special literature. Especial thanks are due the University authorities for their cordial cooperation in the underaking.

Small boats served the purposes of the party for the preliminary work and for occasional short excursions. Later a sailing boat of some size was tried for work on Lake Michigan, but proved too uncertain for continued use, and for the extended trips on the lakes in connection with the plankton work of the last three weeks a small fishing tug was chartered. This was the "Minnie Warren," of 13 tons capacity. Her captain, John O'Neil, has been a successful fisherman for many years and is well acquainted with all the shoals and reefs of the region on which fishing is or has been profitably pursued. We were thus enabled to ascertain the exact location of exhausted fishing grounds and to make collections on them for comparison with material obtained from other points. In general, only single day trips were made, but on one occasion a longer trip of three days to Beaver Island was planned. The first day was spent in making collections at various points en route. It had been planned to investigate the fishing grounds near the island on the second day and return the third by a different route, but a severe storm on the second day upset our calculations and forced us to spend the larger part of the second day in harbor and on the island, and to condense the work of the second and third days into the last. The route of the party may be followed on the map by the numbers of the plankton stations; ix to xiii were made the first day; the night was spent in the harbor at the northern end of the island; xiv was made the second day before the storm broke, after which we returned to the harbor for a compulsory stay of 24 hours, and xv to xvii were stations on the return route of the third day. On the first day some of the party were landed at the lower end of the island and visited the small inland lake there, and on the morning of the third day, while it was yet too rough for work outside, a trip was made to the lake in the northern part of the island. Collections were taken from these lakes for comparison with material obtained in the big lake and in the waters of the main land. This trip afforded much valuable evidence on the present condition of the whitefish grounds, some of the best of which in this entire region were visited and studied. On one other occasion, the day set for work in Grand Traverse Bay, we were overtaken by a storm and compelled to return without accomplishing the object of the trip. Otherwise the work suffered no interruption from bad weather.

The laboratory was opened June 28, when three only of the force were present. Two arrived but a few days later, and these five continued at work until September 1. Their names, and the special part of the work to which the attention of each was devoted, are appended:

Professor Henry B. Ward, University of Nebraska, Lincoln, director; quantitative work, and worms.

Professor C. Dwight Marsh, Ripon College, Ripon, Wis.; vertical distribution and Copepoda.

Dr. Charles A. Kofoid, instructor in zoology, University of Michigan, Ann Arbor; Protozoa.

Dr. Robert H. Wolcott, instructor in zoology, University of Nebraska, Lincoln; Hydrachnida and Insecta.

Mr. Herbert S. Jennings, assistant in zoology, Harvard University, Cambridge, Mass.; fishes and Rotifera.

The following gentlemen who were with the party about a month rendered very valuable assistance in their special line. To some extent they were enabled to examine material collected at other times by various members of the party:

Professor Edwin A. Birge, University of Wisconsin, Madison, Wis.; vertical distribution and Cladocera.

Mr. H. D. Thompson, instructor in natural science, Moline High School, Ill.; plants.

Mr. Bryant Walker, Detroit, Mich.; Mollusca.

It is scant acknowledgment of continued aid and encouragement to say that whatever results the work may have yielded are due to the efforts of these gentlemen. All of them worked under great disadvantages, but with an enthusiasm which begets success, and their best services were offered without compensation in the cause of science. More than this some of them brought to the work of the summer expensive pieces of apparatus without cost of any kind to the Commission. Thanks are especially due to Messrs. Birge, Marsh and Walker for such courtesies. It is only fair to Mr. Thompson, who had charge of the botanical part of the work, to say that he joined the party at a very late date and most unexpectedly, to fill a vacancy, so that he was handicapped by lack of knowledge of the region and of the early work of the party, and was further hindered by poor health during his stay in Charlevoix. In spite of all these disadvantages he did a large amount of work as shown by his report appended hereto.

Valuable assistance in the work of identifying the algæ was given by Mrs. Prudence W. Kofoid. Dr. R. Halsted Ward, Troy, N. Y., was with the party for the last of the season and assisted in the botanical work. After the laboratory closed he voluntarily spent an entire week making collections at various points on the system of connecting lakes in the extreme northern part of the peninsula (see map). These were sent to various members of the staff and were of great value for comparison with the data obtained at Charlevoix. The various stations at which he made collections are indicated on the map by arabic numerals; from these the considerable extent of this assistance may easily be estimated.

The laboratory was honored by numerous visitors, including some scientific men of prominence, who made stays of varying lengths while investigating special problems. Professor W. A. Locy, of Lake Forest University, spent some time there in researches on fish embryology, and Professor C. K. Wheeler, of Michigan Agricultural College, was called to Charlevoix by the discovery of a member of our staff that the Russian Thistle was growing in the vicinity of the laboratory. This was the first reported occurrence of this pest in the lower peninsula. But a small number of plants were found, these in a limited area near the shore and not yet mature. Their timely destruction undoubtedly prevented the species from obtaining a foothold in the region and saved the State a considerable expense for its eradication. Miss Weidemann, of Michigan University, also spent some time in the laboratory, being engaged in the study of various fish fungi.

Mr. Dwight Lydell and Mr. Jesse P. Marks, old and skilled employés of the Fish Commission, devoted their time and energy to assisting the work of the party in various ways. The collections of parasites and of fish stomachs were particularly due to their efforts.

Collections were made and sent to the following persons, who have agreed to report upon the same:

Dr. G. Eisen, San Francisco; Oligochæta.
Dr. R. Blanchard, Paris, France; Leeches.
Dr. W. McM. Woodworth, Harvard University; Planarians.
Dr. C. B. Davenport, Harvard University; Bryozoa.

During the first five weeks the energies of all were devoted to qualitative work on the flora and fauna of the waters. Tows at surface and bottom were taken and examined in the morning, and the afternoon was used for collecting trips to various points. In this way there was obtained a general picture of the life, first in Round Lake on which the laboratory was located, then of Pine Lake and finally of Lake Michigan. Lists were kept of the forms identified, and for this purpose the blank reproduced by Reighard (p. 10) was employed. It should be said that this collective blank, which has been in use for years at the Agassiz Marine Laboratory in Newport, is a form compiled and introduced by Dr. W. McM. Woodworth, of Harvard University. The season at Charlevoix was the second year of its use for lake work, and it has continued to answer its purpose admirably and with very little modification. The blank for recording parasites and that for individual species, given by Reighard (p. 9), were also used at Charlevoix. During our stay it was customary to send some one of the assistants out on fishing tugs from time to time, and to secure in that way specimens of various fish for investigation; the stomach contents of a large number and the parasites of others were obtained and preserved for study.

While the party was thus engaged in recording the mutual relations of the life in the waters, information was secured at the same time as to the character of the waters, of the fishing grounds and of the fish supply. All these were made the basis of the last three weeks work, the quantitative plankton studies, which are treated in detail later.

To the United States Fish Commission, through Commissioner Marshall MacDonald, the party was greatly indebted for the loan of valuable apparatus. At the request of President Whitaker, of the Michigan Board, Mr. MacDonald sent for use in Charlevoix a Tanner deep sea sounding machine* of improved pattern, a Sigsbee water bottle, and a set of Negretti and Zambra deep sea thermometers*, with Tanner improved thermometer cases and accessories. This apparatus was in constant use on our trips; by means of it the depth of all stations was measured, and the temperature of the water taken at bottom and surface. It proved convenient, prompt in action and was invaluable for our work. The only step necessary in rigging it in the fishing tug was to bore a hole of proper diameter in the side rail, fit a step on the deck below to hold the foot and run guy lines in two directions from the apex of the instrument. By a movement of the hand it could be turned out over the rail ready to use or brought back into a resting position. After the return of the apparatus, Commissioner MacDonald had a table constructed for calculating the readings of the register on the sounding machine, and sent the table for use in connection with the records of the summer. The sincere thanks of the party are due to Commissioner MacDonald and the United States Fish Commission for the courtesies thus extended to us.

In connection with the search for young whitefish it was of advantage to have specimens for comparison, and Messrs. Smethurst and Thompson, of Warren, Ind., were kind enough to send a number of specimens raised in their fish ponds. The approximate size of the fish at a certain age, and its general appearance, were known to us in this way. For these specimens sent gratuitously in the interests of fish culture our thanks are due the firm.

While in Charlevoix the party was in receipt of a large number of courtesies from various sources. To acknowledge them in detail would be impossible here. They helped the work materially and aroused in members of the party a friendly feeling towards the place and its residents which will not soon be lost.

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* A detailed description of the apparatus may be found in Report U. S. Fish Com., 1883, p. 57-76, plates 29 to 39.

NOTE.—I feel that an apology is due to the Commission, and no less to the various members in the party for the delay in the appearance of the final report. For this I am alone responsible and can only say that the delay has been entirely unavoidable.

LAKE MICHIGAN.

Lake Michigan stretches from 41° 40′ to 46° 5′ north latitude, and from about 85° to about 88° west longitude; its surface lies at an elevation of about 600 feet above the sea. The lake has the form of an elongated oval extending in general north and south, but the narrower northern end curves decidedly towards the east, so that the western and northern shores form with the continuous shore of Lake Huron a nearly regular semicircle. The extreme length of the lake is about 345 miles; its width is greatest opposite Grand Haven, being there 85 miles and decreasing slightly in both directions, more towards the northern extremity of the lake. At its northeastern end the Straits of Mackinac connect with Lake Huron by an open passage 8 miles wide.

Lake Michigan averages 400 feet in depth, and in some places reaches the extreme of 900 feet or more. Its area is variously given as 22,400 to 25,600 square miles, making the total volume reach 262,500,000 millions of cubic feet, according to one computation.[*] This enormous volume assures comparative stability of the entire mass since the total inflow, and consequently also the outflow are very small in comparison. It is impossible to measure the outflow on account of the size of the Straits of Mackinac and the variability of the flow in them, which depends upon changes in conditions of wind and weather to such an extent that at times the outlet is the seat of a powerful current setting inwards. The inflow is equally difficult to measure, since the tributaries of the lake are none of them rivers of any size, but innumerable small streams, in which the flow is not only extremely variable at different seasons, but is also in most cases entirely unmeasured.

One method of estimate yields, however, results which show clearly the minimal amount of the change even under the most favorable circumstances. The entire area of the drainage basin of Lake Michigan is given as 70,000 square miles, and according to the same authority[†] the lake covers 23,400 square miles of that amount, or the area of the entire basin is only three times that of the lake itself. The normal rainfall of the region is given by the tables of the U. S. Weather Bureau as from 32 to 36 inches per annum.[‡] A yearly precipitation of 35 inches, which is more than the average for these places and certainly not less than the normal for the entire region, would mean a total of three times that amount, or 105 inches, if all of it were conserved and reached the lake. According to the investigations of Russell (88), the annual evaporation from free water surfaces, in this latitude varies from 20 inches at the head of the lake to 34 inches at its southern end, or about 27 inches for the average of this area. Deducting this and regarding the evaporation from the land and from the streams en route to the lake as *nil*, we find that the level of the lake would be raised 78 inches, or 6½ feet, by the total annual rainfall. Of course the amount of outflow in any single year is dependent on other factors as well as the rise in level by additions from the surrounding country, but on the average the amount gained by inflow and the amount lost by outflow in a single year are equal. The total change in volume during a year is then six and one-half feet; or, on the basis of an average depth of 400 feet, it would require 62 years to change the entire volume of the lake. This is certainly too much, since the loss by evaporation from the land and from streams in transit is a considerable percentage of the total. I am unable to find any definite information as to the amount lost in this way; if, however, it equals one-third the loss from free water surfaces, the deduction for an area equal to the lake would be 9 inches yearly, for double that area 18, which deducted from the figures given above would make the annual gain of the lake 5 feet. This would mean a change of *one-eightieth of the entire volume in one year*. The actual change is probably somewhat less than this. Under these conditions one may justly regard the volume of the lake as stable and as such sharply in contrast with those which obtain in those lakes which have hitherto been the object of biological investigation. In Lake St. Clair, which represents perhaps the other extreme, the inflow and outflow are sufficient to change the entire volume of water in the lake in less than six days.

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[*] Not only do various authorities differ widely in the figures given, but in Reclus (90) from whom these statistics are quoted, there stands in the table, p. 250, area, 25,600. depth 870, elevation 595, while the statistical table of the appendix to the same volume (p. 464) gives the figures as 22,400, 700, and 576.

[†] Encyclopedia Britannica, IX Ed., article on St. Lawrence.

[‡] Green Bay, 33; Milwaukee, 32.2; Chicago, 35; Grand Haven, 35.6 inches. (Report of Chief of the Weather Bureau for 1891–92, pp. 444–5.]

Uniformity of distribution within the lake is brought about by the constant currents. These have been the subject of especial investigations by the U. S. Weather Bureau and the surface currents of the Great Lakes are given in a report by Harrington (95). From the chart of Lake Michigan in that atlas it appears that a general southerly current runs parallel to the west shore, a short distance from it, and a northerly current returns, the length of the lake, close to the eastern coast. In the southern end of the lake these currents form parts of a circular movement of which the upper cross current is below Grand Haven. Somewhat further north a broad indefinite stream sets from the western to the eastern longitudinal currents and near the upper end of the lake a whirling current surrounds the Fox and Beaver Island group. The northerly current does not seem to pass out through the Straits of Mackinac, through which the water runs in both directions at various times and under various conditions of wind and weather, but it is reflected towards the western shore. In velocity the currents vary from at least 4 to 20 miles a day, while in the extreme case it may reach 40 to 90 miles in the twenty-four hours. The movements of these currents produce then a circulation within the lake itself, and constitute an extremely important factor in the distribution of the life in the water. In addition to these regular currents there are also the irregular movements of the water due to winds and the so called tidal waves or *seiches*, both of which contribute to produce uniformity of distribution.

The lake shore presents a great diversity of physical features. At the southern end the shores are flat, sandy and entirely free from outlying islands; towards the north they become higher, rocky and jagged while the sharp promontories are continued into extended reefs and series of islands, some few of which even attain a very considerable size. Along the lower half of the lake the shore is entire or at most faintly indented by long sweeping curves, but northward one finds numerous deep bays and sharp promontories. Two great bays face each other on opposite shores of the lake near its upper end, forming the most prominent breaks in the entire shore, and so located as to apparently balance each other. Green Bay on the Wisconsin shore is somewhat larger than Traverse Bay, its counterpart on the Michigan side, but the latter is noteworthy for its extreme depth. Both of these bays have long been famous fishing grounds, and the waters of the Traverse Bay region still continue to furnish an important part of the whitefish supply. It seemed wise to carry on the work from some central point in this region and Charlevoix was selected as the site for the laboratory. The town (see map) is located on the eastern shore of Lake Michigan, midway between Grand Traverse and Little Traverse Bay. The Beaver Island group which lies to the northwest is connected to the mainland by the "ten fathom" line, which marks out roughly the limits of an old peninsula that made this portion of the main lake a bay in former times. The northward current of the lake already referred to sweeps up through this region and circles around the islands. Though the opening between the islands and the mainland through which it runs is less than ten fathoms (18m.) deep, the path followed from the southward is marked by a sublacustrine valley of considerable depth. Stations xi and xvii which lie about in the line of this depression show a depth of 112 and 130 meters, respectively.

A pier of some length terminated by a lighthouse marks and guards the entrance to a small channel which joins Lake Michigan to Pine Lake, one of the largest bodies of water within the lower peninsula of Michigan. Midway in the course of the stream is Round Lake, a nearly circular sheet of water half a mile in diameter, the shores of which are lined by the docks and crowned by the houses of Charlevoix. Here was located the laboratory at the very edge of the water and within easy reach by boat of both the main lake on the west and Pine Lake on the east (Pl. IV). The advantages of the situation were unsurpassed for the work in hand. The numerous small lakes in the surrounding country afforded every advantage for easy comparison of life in ponds, among which were many well stocked with game fish, with life in larger bodies of water. Pine Lake, with its 96 miles of shore line furnished wide variations in depth and character of bottom, while Lake Michigan in the immediate vicinity presented areas of open water and well protected bays, shallow and deep water, with sand, cobble stone and rocky bottom. There were not wanting areas generally believed to be spawning places for the whitefish, nor fishing grounds of present and past repute, so that it was possible to find within comparatively narrow limits the factors necessary to be compared in attempting to begin the solution of the whitefish question.

I was unable to ascertain the exact length of shore line presented by Lake Michigan and hence could not calculate precisely the absolute and relative shore development. Estimates made from the government chart show that both are decidedly less than the figures given for Lake St. Clair by Reighard (p. 12). The area of shallow water is still further limited by the comparative steepness of the shore. The ten fathom line (18m.), as drawn on the chart, leaves an extremely narrow margin of shallow water; and yet the limit set by this line is three times that of the deepest point in Lake St. Clair. The influence of the limited shore line and of the insignificant shallow littoral region on the conditions of existence will be discussed elsewhere in the report.

FLORA AND FAUNA.

In general it may be said that the number of species found in the waters of the Charlevoix region was not so great as from Lake St. Clair the year before. Reighard reports a total of 623 species from the latter place, while the total number recorded from Charlevoix was only about 500, although an equally careful search was made. The most noticeable difference, in the number of species of plants recorded, was due in part to the short time which Mr. Thompson spent in Charlevoix. Some facts of importance concerning the various groups may be recorded in this connection.

PLANTS: Of the larger plants so abundant in Lake St. Clair and in the smaller inland lakes it was evident at an early period in our work that their relative scarcity exercised an important influence in limiting the littoral fauna of the lakes. Reighard shows that the yield of the larger plants in a lake is dependent upon the amount of shallow water. To this may well be added as a second important factor the permanency of the shore, the littoral area. If, owing to storms or currents, the bottom of the shallow area is continually shifting, or if the beach is disturbed at each storm by the heavy waves rolling in from the deep water, there is little chance for the development of shore plants or such as grow in shallow water. And as a matter of fact the only considerable bed of larger plants which was encountered in Lake Michigan, occurred in the sheltered High Island Harbor. (Pl. V, station xv.)

These two factors serve to explain the limited development of the larger plants in the Charlevoix region, and the casual visits paid by members of the party to inland lakes in the vicinity which resulted in the discovery of much crowded masses of shore and bottom vegetation in those smaller and shallower lakes, go to strengthen the force of the conclusion. I do not feel sure that the deficiency in the group of filamentous algæ noted by Mr. Thompson in his report appended to this paper, can be explained on the same ground alone, but certainly these factors are of some importance in this connection also.

Among microscopic plants Mr. Thompson calls attention also to the entire absence of Desmidiæ* from the waters of Lake Michigan and also from those of both Round and Pine Lakes. The Diatomaceæ were, however, extremely abundant, both in species and in individuals, and were according to Mr. Thompson's observations most plentiful in the deep towings. This may be due possibly to the great transparency of the water. A more detailed account of the plants, together with a list of the species determined and data on the distribution of various forms may be found in the report of Mr. Thompson (Appendix I, p. —). The amount of material collected is actually very large if it be remembered that Mr. Thompson was called in at a late date to fill a vacancy in the party, that he was able to be with us only a few weeks, at the end of our stay in Charlevoix, and that he had to contend with numerous difficulties apart from the brief time at his disposal.

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*Two species of rare occurrence were recorded at the laboratory during the summer.

In addition to those found by Mr. Thompson, the following species of microscopic plants were recorded at the laboratory during the summer.

Anabaena flos-aquæ Kg.
Cocconeis transversalis Greg.
Cyclotella operculata K.
Eurastrum inerme Lund.
Gomphonema acuminatum Ehr.
Merismopidia convoluta.
Navicula major K.
    maxima.
    producta S.
Pediastrum beryanum.
Stephanodiscus niagare E.
Treyblionella scutellum Smith.

ANIMALS: The following notes on various groups of animals are deserving of special mention or of particular explanation in this connection. A list of the groups represented in fresh water, together with the common names of these groups is given by Reighard (p. 16).

Protozoa: A very full report on this group by Dr. C. A. Kofoid is appended (p. –). These forms constitute one of the chief elements of the plankton, furnishing as they do the simplest animal food and being one immediate source of food for the smaller crustacea which in turn become the prey of various fishes, they are an exceedingly important factor in fish economy. This was pointed out by Ryder (81), who, however, regarded the Protozoa only as an *indirect* source of the food of fishes. They are indeed important from this standpoint alone; but the work of Peck (94) establishes the value of the Protozoa and Protophyta of the plankton in one case at least, as a direct source of food supply also. Thus far no fresh water fish is known to have similar habits, but investigations should be made as to whether the same is not true to some extent at least of our lake herring. It is interesting to note the confirmation in Dr. Kofoid's report of the absence of a littoral zone, and the freedom from shore mixtures of Lake Michigan plankton, as shown by a study of the protozoan representatives. The number of species which are characteristically limnetic is large here, being eighteen for Lake Michigan, as compared with thirteen in Plöner See and seven in Lake St. Clair. These forms are widely distributed and none of the species seem to be exclusively characteristic of this region. The list of species would have been considerably extended, except that our attention was confined chiefly to a study of the plankton, while collections from the shores and from the inland lakes were obtained only casually.

Coelenterata: No fresh water sponges were found in the lakes at Charlevoix. Both the white and the green *Hydra* were met with occasionally in bottom tows. Their comparative rarity is unquestionably due to the scarcity of vegetation to which they ordinarily attach themselves, since in the collections brought back from the inland lakes north of Charlevoix by Dr. R. H. Ward they were exceedingly numerous. In some bottles from that region the white *Hydra* was found in such numbers as to constitute the bulk of the material in the entire haul.

Worms. *a.* **Turbellaria:** (Non-parasitic flat worms.) The following species were found on algæ collected from the old channel, Round Lake:

Mesostoma viviparum Silliman.
Vortex sp.
Microstoma lineare Or.
variabile Leidy.

An unidentified form occurred once or twice in the bottom tow and four vials of specimens were set Dr. W. McM. Woodworth for identification. He reports two species found in the vials, *Vortex armiger* O. Schmidt, and *Mesostoma* n. sp. described later in this report together with other data on this group. (App. IV.)

b. **Parasitic Worms:** A total of 1410 parasites were obtained from 115 specimens representing eighteen species. These included *Coregonus artedi*, *C. clupeiformis*, *C. prognathus*, *C. quadrilateralis*, and *Salvelinus namaycush*. The whitefish and trout were in some cases badly infested with tapeworms and *Echinorhynchi*; but on the average there were fewer parasites than in the fish from Lake St. Clair examined the year before. A single free specimen of *Mermis* and a few of *Gordius* were taken from Round Lake and Lake Michigan respectively.

c. **Oligochaeta:** These worms were not so frequently met as in the Lake St. Clair work. A small collection, comprising 6 vials of alcoholic specimens, was sent by Dr. Eisen for identification. The relative scarcity was due no doubt to the scanty littoral and bottom vegetation, on which they are commonly abundant and from which certain species were collected in large numbers in Lake St. Clair.

d. **Hirudinea:** The leeches were represented by several very large species, and numbers of other forms, all of which are in the hands of Professor Raphael Blanchard, who will make a report on them in detail. One very interesting striped form, *Ichthyobdella punctata* Verrill, was present in large numbers on the fish lifted in gill nets. They attack mostly whitefish and are found in abundance. Thousands are strewn over the nets, boxes, and even the deck itself when the seine is hauled in.

e. **Bryozoa:** In dredgings made on the Middle Ground, Traverse bay, at a depth of from 23 to 36 m., a considerable number of colonies of these forms were collected. With them were dredged scanty filamentous algæ. The Bryozoa were submitted to Dr. C. B. Davenport, of Harvard University, who very kindly determined them. He reported that *Paludicella Ehrenbergii* van Ben. and *Fredericella sultana* Blumenbach, were abundantly and typically represented in the mass sent him, and that the stocks were evidently living when found. *Cristatella mucedo* Cuv. was represented by a part of a statoblast only which had undoubtedly floated down from a higher level. The first two species are an interesting addition to the deep water fauna of the lakes, and I think the deepest recorded occurrence of Bryozoa in fresh water. Agassiz ("Three Cruises of the Blake") records marine forms from a depth of nearly 900 m.

The forms mentioned above were also obtained from "honey comb" rock brought up in gill nets from about the same depth in the vicinity of the reef between Charlevoix and Beaver Island. (See map, station ix).

f. **Rotatoria:** These forms constitute an important part of the microscopic fauna of the lakes. One hundred and ten species were reported in 1893 from Lake St. Clair. Last summer only ninety-four were found in the entire Charlevoix region, and but fifty-eight of these occurred in Lake

Michigan or in the immediately connecting waters of Round and Pine lakes. The limnetic (pelagic) species were well represented, being in number only three less than the true limnetic species of Lake St. Clair, but the absence of shore and bottom vegetation precludes the development of the large number of littoral and bottom forms found in smaller and shallower lakes. Thus only eight bottom species in all are reported from Lake Michigan. Mr. Jennings, in his report on these forms, printed as an appendix, calls attention to some biological facts of great interest, such as the accumulation of the Rotifers near the surface in the day time and the rapid variations in the number of individuals and in the ruling species of the plankton. Out of the ninety-four species recorded twenty are new to Michigan and one new to science.

Crustacea: Of this class the following orders were represented in material obtained at Charlevoix. These forms constitute the most important element of fish food and are found in large numbers in the shore, the bottom and the limnetic faunæ.

a. **Cladocera:** Between twenty-five and thirty species of these forms were taken at Charlevoix. They were most abundant in the smaller inland lakes, no less than twenty species being recorded as the result of a half day trip to Twenty-Sixth lake. In the larger lakes they form a less important element of the faunæ. No detailed report on the number or frequence of these forms has yet been made.

b. **Copepoda:** A special report on this group has been published (Marsh, 95), from which a few quotations are made here. "From the standpoint of the pisciculturist, perhaps no class of animals outside the fishes themselves is so important and interesting as the Entomostraca. It is a well known fact that these minute crustacea form the entire food material of the young of some of our most important food fishes, and in many cases constitute a large part of the food of the adults."

With reference to the representatives of this group in the Charlevoix region, Marsh says (p. 4), "It is interesting to note the greater richness of the copepod fauna of our lakes as compared with those of the continent of Europe. Zacharias finds seven species of copepods belonging to the Cyclopidæ and Calanidæ in the Plöner See. In Lake Michigan there are nine, and that includes no littoral species; in the two lakes on Beaver Island there are eight, in Pine Lake nine in Round Lake eleven, in Intermediate Lake eleven, and in Lake St. Clair sixteen. The larger number in Lake St. Clair is probably explained by the fact that, being very shallow, it has the species of the smaller bodies of water and of the stagnant pools, and in addition, because of its connection with the Great Lakes, has also their limnetic species.

"Pine Lake is peculiarly poor in its number of species; this is strikingly apparent when we compare it with Intermediate Lake. Pine Lake was very thoroughly examined, and it is likely that we are acquainted with all the species occurring there, and yet the number is only eight. All the collections from Intermediate Lake were made in one day by a party which went down from Charlevoix and remained only a few hours, and yet the number of different forms is eleven. Intermediate Lake seems to be an usually rich collecting ground, for, with the exception of Lake St. Clair and Round Lake, no other lake shows such a large number of species, and both Lake St. Clair and Round Lake have been very thoroughly explored. Moreover, in the case of Round Lake, several of the species may be considered as immigrants from Lake Michigan."

In a letter of recent date Professor Marsh says:

"There are no characteristic species in Lake Michigan at Charlevoix, as the fauna of the Great Lakes is, so far as I can make out, identical. Lake St. Clair has some stagnant water forms in addition to those commonly found in the lakes. From the stations about Charlevoix I have 17 determined species. There was besides at least one species of *Ergasilus*, one or more of *Canthocamptus*, and the parasitic forms which I have not worked out at all."

In the report referred to above are given a table of distribution and keys for determining the various species in the groups which are found in Michigan. For further details the original should be consulted.

c. **Ostracoda** are not uncommon in Round and Pine lakes, they are not, however, sufficiently numerous to be an important element of the plankton. The species obtained have not been determined as yet.

d. **Amphipoda:** There are two species of amphipods which are characteristic in their distribution. *Hyallella dentata* Smith is found in large numbers along the shores of Round Lake (Pine Lake?), and the inland lakes. It was not reported from Lake Michigan though it may well be present in the immediate vicinity of the shore. In deep water its place is taken by *Pontoporeia Hoyi* Smith which came up in every haul of the dredge, and was frequently present in enormous numbers. This species forms one of the chief sources of food for various species of whitefish. (See p. 21.)

e. **Podophthalmia:** The Stalk Eyed Crustacea are represented by shrimp-like forms and by the crayfishes. A single species of the first, *Mysis relicta* Lovén, occurs in Lake Michigan in deep water; from 24 to 130 m. (the deepest station) it was abundant everywhere that we tried the dredge. On one occasion a bottom tow with the runner net brought up a large number of individuals which were kept alive in a pail for a time, but soon died, perhaps on account of the rise in temperature of the water. They are among the most transparent and active of fresh water Crustacea and yet furnish much the largest percentage of whitefish food afforded by any one species (see tables p. 21). For themselves they appear to rely largely upon the Copepods of the plankton for food. In spite of their abundance we did not take a single immature form in our nets.

Two species of crayfish, *Cambarus propinquus* Ger., and *C. virilis* Hagen, were found both in the main lake, and in the connecting waters of Round and Pine lakes These species came up in large numbers on the gill nets of the fishermen and were taken in the trawl as well as caught in shallower water along shore. They furnish an important element of the food of the larger fish.

Hydrachnidæ: The water mites seem to be very abundant at Charlevoix. With reference to the group Dr. Wolcott reports:

"Of Hydrachnidæ, to which very careful attention was devoted, owing to personal interest in the subject, 43 species were taken belonging to 16 genera; of these 23 species and 4 genera were not represented in the collection from Lake St. Clair. Numerous specimens of a mite identified in the previous collection as a species of Oribatidæ, were also obtained."

Insecta: A disappointingly small number of forms both in species and individuals was found in Charlevoix waters. The absence of the littoral and bottom vegetation, which in Lake St. Clair afforded shelter and support to a host of larvæ, evidently accounts for the deficiency in this respect. That this was clearly the cause became apparent on the cursory examination of the smaller inland lakes of the region which sheltered among the littoral and bottom vegetation countless larvæ. No attempt was made to collect or include in the list these forms from the smaller lakes. With the scarcity of insect larvæ goes hand in hand the absence of those fish which depend largely or entirely upon these forms for food, and which were abundantly found in Lake St. Clair. Dr. Wolcott listed 77 species from Charlevoix, determined as follows: Odonata 9, Ephemeridæ 7, Perlidæ 1, Phryganidæ 13, Hemiptera 6, Coleoptera 18, Lepidoptera 3, Diptera 20, and adds concerning them "To these must be added a number of species of aquatic habits during a whole or part of their existence which were, however, collected not in towings or dredgings, but only in the adult state; these are sufficient to bring the total list of aquatic forms observed up to considerably over a hundred. It was to be expected that the experience of the previous year at Lake St. Clair would have rendered possible the collection of a still larger number of species, but the conditions were to some extent unfavorable. Both Pine and Round Lakes, deficient as they were in vegetation, exhibited an equal deficiency in the number of species of insects, although the latter were present in considerable numbers wherever vegetation occurred, as it did at some points. Shallow pools along the shores of Pine Lake supported an abundant fauna, but since they hardly came within the territory embraced in the scope of the party's work, no extensive collections were made from them."

"Dredgings from Lake Michigan in moderate depths, especially when over beds of *Chara*, etc., brought to light a considerable number of insects which were in no wise peculiar. Very interesting, however, was the occurrence on one occasion of a species of *Nemoma*, one of the Perlidæ, in the deeper parts of the lake in the vicinity of Charlevoix."

Mollusca: This group was very thoroughly studied by Mr. Bryant Walker whose report is found in appendix V. I would call attention here to his remarks on the scarcity of the large bivalves which are an unimportant element of fish food and the universal abundance of the smaller forms, both univalves and bivalves, which constitute so important a factor in the food supply of the lake fish. (See tables p. 21). While Mr. Walker calls especial attention to the large number of forms found in beds of *Chara*, it is equally true that the surface of the boulder covered areas of bottom, so plentiful a short distance off shore in that part of Lake Michigan appears peppered with small snails; and together with crayfish they constitute the chief animal forms taken in dredgings in this region. These univalves subsist in large part on the minute algæ derived from the plankton, while the bivalves are entirely dependent upon this source for their food supply. Here there is then but one intermediate stage between the life of the plankton and the whitefish. Mr. Walker also notes the poverty of the molluscan fauna in Pine Lake. Details with reference to the various species and their distribution are to be found in the appendix. It is not too much to say that no group was more thoroughly and accurately worked up than this and the importance of these data for the whitefish investigation is apparent on examination of the tables of whitefish food, already mentioned.

Vertebrata: Water birds are not as common on the lake as they were at Lake St. Clair and turtles were found only in the smaller inland waters. Amphibians were not noticed in Lake Michigan at all and were rare in the other waters examined. Only a single specimen of the "mud puppy" (*Necturus maculatus* Raf.) was found, and that in the old channel between Round and Pine lakes. This species is extremely abundant in Lake Erie and Lake St. Clair and destroys an enormous number of white fish eggs, the Necturi taken in the Detroit river in the fall being gorged with the freshly laid eggs. The apparent rarity of the form further north is hence fortunate.

The following list shows the species of fish taken in various places as indicated: C, old channel between Round and Pine lakes; M, Lake Michigan; P, Pine Lake; R, Round Lake, (Pl. IV). The list is by no means complete since particular attention was paid only to the important food fish and to smaller forms captured by chance in the search for young whitefish. The identification of the smaller forms was made by Mr. Jennings, while we worked together on the various species of *Coregonus*. We had determined the Lake Michigan "Long Jaw" as an undescribed species, and it was only in the fall that on receipt of the paper by Smith (94) I saw it was identical with his species *C. prognathus*.

Scientific Name.	Common Name.	Locality
Ambloplites rupestris (Raf.)	†Rock bass	R.
Ameiurus melas (Raf.)	†Bullhead	C.
Catostomus teres (Mitch.)	†Sucker	P.
Coregonus Artedi LeS.	†Lake Herring	M.
clupeiformis (Mitch.)	†Whitefish	M.
quadrilateralis Rich.	†Menomonee	M.
(?) *tullibee* Rich.	Long Jaw (?)	M.
nigripinnis (Gill.)	†Blackfin	M.
prognathus H. M. Smith	†Long Jaw of L. Michigan	M.
Cottus Richardsoni Ag.	*Miller's Thumb	M. R.
Etheostoma nigrum Raf.	*Sand Darter	M. R.
caprodes Raf.	*Log perch	M.
Eucalia inconstans (Kirtland)	*	M. P.
Lota lota (L.)	†Lawyer	M. P.
Micropterus dolomieu Raf.	Small mouth Black Bass	R.
Notropis deliciosa (Gir.)	*	C.
megalops (Raf.)	†Common Shiner	R.
Percopsis guttatus Ag.	*	M.
Perca flavescens (Mitch.)	†Perch	R.
Salvelinus namaycush (Wal.)	†Lake Trout	M.

Names after Jordan, Manual of the Vertebrates, fifth edition, Chicago, 1890.

Half a dozen species of young fish or small forms are yet unidentified. If these and the fish taken in the smaller inland lakes were both added the list would be considerably extended.

The food relations of the various forms listed in the foregoing can not be given at present in more than general terms. For a discussion of this subject and a valuable table expressing some of these relations in synoptic form the reader is referred to Reighard (95, pp. 23 and 24).

One striking faunal peculiarity appears on examination of the preceding account of the various groups to be generally characteristic not only of Lake Michigan, but also in great part of Round and Pine lakes. It is the absence of the littoral flora and fauna. The abundance of life which characterized the shore region on Lake St. Clair is here entirely lacking.

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* Taken in trawl in various localities.
† Examined for food and parasites.

It may well be that all other deficiencies are due to the absence of littoral vegetation, the reasons for which have already been discussed. At any rate, the barrenness of the littoral zone eliminates from the question of the food supply of this region one element which in Lake St. Clair was of extreme importance.

Mention has been made of the limited bottom vegetation and of the absence of certain forms of animal life ordinarily found in connection with the plants of the bottom. This matter will be discussed further in another part of the report. Here may be recorded merely the limited development of this source of food supply in this part of Lake Michigan.

To one small group of forms, the various species of whitefish, particular attention was paid and the results of this study are embodied in a special section of this report.

THE WHITEFISH.

Eight species of *Coregonus* are known to occur in the Great Lakes; they are the common or true whitefish, *Coregonus clupeiformis* [Mitch.], the "blackfin" *C. nigripinnis* [Gill], the "long jaw," *C. prognathus* H. M. Smith, the lake herring or cisco *C. Artedi* Le Sueur, the tullibee or mongrel whitefish, *C. tullibee* Richardson, the Menomonee whitefish, *C. quadrilateralis*, Richardson, the "Soo" whitefish or whiting, *C. labradoricus* Richardson, and the Lake Michigan cisco or the lake "mooneye" *C. Hoyi* [Gill]. The last four from their rarity or small size, are of little importance commercially, and only one of them the Menomonee whitefish, was seen at Charlevoix. All of the first four, however, were obtained there, and the first three were the object of especial study. They are the species ordinarily marketed and are sold indiscriminately under the name whitefish, although the fishermen distinguish them easily. In fact the "long jaw" was constantly picked out for us as a distinct form by the fishermen, and after numerous efforts to make it fit the description of some known species, Mr. Jennings and I were forced to admit its distinct character. Early in the fall the paper by H. M. Smith (94) fell into my hands, and the identity of the Charlevoix form with the new species described therein was at once apparent.

The habits of the whitefish are only meagerly described in our literature. Since Milner (74) nothing more than scattered details have appeared, and a good account of the biology of this group is yet to be written. The work at Charlevoix was not extensive enough to add greatly to our knowledge; there are, however, some observations of value made there which may be recorded in this place.

The horizontal distribution of the four species is, so far as our observation extended, uniform; but the vertical limits seem to be very different. This is mentioned in the work of Milner, but our own observations, and also the reports of the best fishermen, seem to indicate even a more definite location for each species. It seems that the lake herring is a surface fish and is taken in gill nets only near the surface; the true whitefish is caught in water as shallow as twenty feet, but is most common between twelve and twenty fathoms. The long jaw is rarely found in twelve fathoms; it is, however, abundant in depths of from twenty to twenty-five fathoms, but does go somewhat deeper, while the blackfins are rarely met in less depth than forty fathoms. This vertical distribution is so definite and so well known that the catch of a gill net at any given depth may be predicted with considerable accuracy. It is the summer range of the fish and is modified at the spawning season. One naturally suggests temperature as the ruling cause for this vertical limitation of distribution, since, as will be seen later, the food of these various species has a much wider vertical range than the species itself, and since the accounts given by fishermen of the winter limits of the species correspond in general to the temperature changes. This matter should be the subject of special study during the entire year in connection especially with accurate and extended observations on the temperature of the water.

In the next place our entire knowledge of the food of the young whitefish, and in fact all other information with regard to the fish in the first year of its life, depends upon inference. Forbes (82) has furnished the only experimental information on this subject. He placed several thousand whitefish fry in a tank fed by Lake Michigan water and supplied them with an abundance of organisms obtained from the lake by a tow net. From this, which is identical with the plankton mentioned elsewhere in this report, the fry selected chiefly small Entomostraca. Forbes says (p. 781), "The entire number of objects appropriated by the sixty-three fishes [out of 106 examined] was as follows: *Cyclops Thomasi*, ninety-seven; *Diaptomus sicilis*, seventy-eight; *Anurœa striata*, twenty-nine; *Daphnia hyalina*, one." From this he concludes that "the two species of Copepoda, *Cyclops Thomasi* and *Diaptomus sicilis*, are certainly very much more important to the maintenance of the whitefish in the early stage of independent life than all the other organisms in the lake combined." Interesting and valuable as these experiments are, it should be noticed that the evidence is not complete. The fact that in captivity the fry eat these two species in particular is no proof that in nature their food is the same. In the Agassiz Marine Laboratory at Newport I have easily reared young toadfish, a pure bottom fish, on the small crustacea of the plankton. It would be hardly safe on this evidence to regard the young toadfish as normally plankton eaters; the probability is that the natural food of the young was substituted by nearly related forms of *approximately the same size.* Forbes notes that the *Cyclops* was the smallest of all the Entomostraca in the plankton and that the *Diaptomus* was the next in size. This is also the order of preference expressed by the whitefish fry as shown by the number of each species eaten. Reighard (94, p. 40), expresses the opinion that the whitefish fry are more probably bottom feeders. If so, their natural food will then be some of the small bottom crustaceans of no doubt approximately the same size as the two just mentioned, most likely closely related species, but not these forms which are limnetic in character. The nature of the first food of the whitefish fry was clearly demonstrated by Forbes in the discovery of the pharyngeal teeth, which are wanting in the adult, and which point unmistakably to the carnivorous habits of the young. They prey undoubtedly on the Entomostraca; the exact species on which they subsist, however, yet remain to be established.*

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*The matter can only be determined experimentally and I am informed by correspondence that the Michigan Fish Commission, during the past spring, has carried out a series of experiments by planting the fry in boxes supplied with gauze gratings. The boxes were anchored in favorable localities at the surface and near the bottom and a certain number of the fry taken periodically and examined for food. The results of these experiments may well be awaited with great interest.

It was the hope of those interested in the work at Charlevoix that some of the young whitefish hatched in the spring might be caught, and thus evidence furnished as to the food and habitat of the fish during the first year of its life. At the very beginning of the stay an assistant was set to scouring the shores, inlets and shallow places in order to catch all the young fish which could be found; a large number of different species was collected, but none of the whitefish family. A trawl was constructed and used on all of our August excursions into Lake Michigan with the fishing tug. It was tried in waters of various depths and over all bottoms where it could be run and was successful in obtaining a number of species of small fish from these localities (see list on page 17), but no whitefish. The bottom of Lake Michigan in the Charlevoix region is not very favorable for the use of a trawl, as even the stretches of sandy bottom are strewn with occasional boulders, and in the course of our work the trawl was first lost and recovered only after a long search, and finally on the following day torn to pieces. In future work a fine meshed silk gill net would, I believe, be more likely to succeed in catching the young whitefish.

During severe storms young fish are thrown up on the beach of Lake Michigan near Charlevoix, and from this source we obtained immature specimens of the lake herring, of the Menomonee and probably of the long jaw, but none of the true whitefish. The specimens were from three to five inches long and were as small as any ever obtained there. They were probably fish which had been hatched in the spring of that year. The absence of young whitefish in spite of the large catch of the adult fish at this point shows either that the young are more limited in their distribution than the adult and hence are not found at this point, or that they live deeper than the young of other species mentioned and thus are not affected by the wave action in time of storm. Some account of the food of the adult whitefish is given by Milner (74, p. 44) and Smith (74). The number of specimens reported was small, and also the importance of each element in the total amount was left unnoted; furthermore the food of the allied species has received no attention. Hence it seemed wise to devote careful attention to this point and ascertain as exactly as possible the character of the food and amount of each element in it for each of the species of whitefish. A large number of stomachs of whitefish were examined and the results of this study are expressed in the following tabular forms. The specimens examined were from widely separated fishing grounds, representing more than the limit of territory covered by the map of the Charlevoix region given in this report (Pl. V). In the identification of the species of food animals, all the members of the laboratory force participated, and the estimated percentages were similarly controlled so that every effort has been made to reduce the error of such observations to a minimum. The first table presents the results of observations on the food of the true whitefish.

Name of food animal.	Specimens of *Coregonus clupeiformis* examined.														Av.
Mysis relicta Lovén	95	70	----	70	5	----	5	----	----	35	----	----	----	----	20
Pontoporeia Hoyi Smith	----	5	30	----	----	95	85	85	65	----	80	70	90	*	43
Eurycercus lamellatus	----	----	----	(*1*)	----	----	----	----	----	----	----	----	----	----	----
Total Crustacea	95	75	30	70	5	95	90	85	65	35	80	70	90	*	63
Limnæa catascopium Say	----	----	----	----	----	----	----	----	----	----	----	----	----	(*10*)	----
sp. (*juv.*)	----	----	----	----	----	----	----	----	(*1*)	(*4*)	----	----	----	----	----
Physa sp. (*juv.*)	----	----	----	----	----	----	----	----	----	----	----	----	----	(*3*)	----
Planorbis parvus Say	----	----	----	----	----	----	----	----	----	----	----	----	----	(*10*)	----
Amnicola limosa Say	----	----	----	----	----	----	----	----	----	----	----	----	----	(*8*)	----
lustuca Pils.	----	----	----	----	----	----	----	----	----	----	----	----	----	(*2*)	----
porata Say	----	----	(*1*)	----	----	----	----	----	----	----	----	----	----	----	----
Valvata sincera Say	----	----	(*5*)	5	----	----	----	----	----	10	----	5	----	10	2
tricarinata	----	----	----	----	----	----	----	----	----	----	----	(*1*)	----	(*1*)	----
Sphærium striatinum Lan.	----	----	----	----	55	----	----	----	----	----	----	(*1*)	----	(*3*)	4
n. sp.	----	----	(*1*)	----	----	----	----	----	20	(*1*)	----	5	----	10	3
Pisidium (several species)	(*3*)	5	60	15	35	2	1	----	10	35	(*1*)	10	----	60	16
Total Mollusca	*	5	60	20	90	2	1	0	30	45	*	20	0	95	26
Chironomid larvæ	*	8	5	5	*	3	8	10	*	*	15	*	5	----	4
Hydrophilid larvæ	----	----	----	(*1*)	----	----	----	----	----	----	----	----	----	----	----
larvæ	----	----	----	----	----	----	----	----	----	----	2	5	----	----	----
Total Insecta	*	8	5	5	*	3	8	10	*	*	17	5	5	----	5
Small fish	----	12	----	----	----	----	----	----	----	15	----	----	----	----	2
Fish eggs	----	----	----	----	----	----	----	----	----	----	(*6*)	----	----	----	----

1, 3, 5, etc. = percentage of each form in total food mass estimated from volumes.
(*1*), etc. = number of individuals found constituting always less than 5%.
* = trace, or a few specimens, constituting a small uncertain amount or less than 1% of total.

In addition to objects mentioned small brown stones were very common, and in instances formed one-fourth or one-fifth of the total mass; they were not included in the percentages as they did not seem to be a part of the food proper. A trace of filamentous alga (*Cladophora*) was frequently encountered in the stomach contents where its presence was apparently accidental. A considerable number of stomachs were examined which were empty, or in which digestion had proceeded so far that the computation of percentages was uncertain. Both classes are omitted from the table, although so far as could be seen the latter would not have modified the results appreciably.

Summarizing the results given in the table it will be seen that among these fourteen specimens

Pontoporeia constitutes from 0 to 95 % of the total food, averaging 43 %.
Mysis " " 95 to 0 " " " " " 20 %.

The two forms seem not to be found together in considerable amounts, but the presence of the one indicates the absence, or at most, presence in a trace of the other, making thus the average percentage of crustacean food 63. This alternation seems to indicate a difference in the distribution of the two forms so that the whitefish are likely to find one or the other, but not both on the same feeding ground.

This element is never entirely absent, and, on the other hand, forms two-thirds or more of the entire food mass in ten cases out of fourteen. It is clearly not only the most important element of the food, but is on the average more prominent than all others put together.

Pisidium	constitutes	from	0 to 60 %	of the	total	food, averaging	16 %.
Sphærium	"	"	0 to 55 %	" "	"	" "	7 %.
Valvata	"	"	0 to 10 %	" "	"	" "	2 %.

Other species of mollusks are present in varying small amounts, making the total amount of food furnished by these animals on the average 26%. In three cases out of fourteen this was the bulk of the entire food, and in two instances it was entirely lacking.

The insect larvae, chiefly Chironomids, are a small though comparatively constant part of the food, constituting at most only 15%, and on the average about 5% of the whole. The two cases in which small fish were found, suffice to make this element average 2% of the whole. Whether it is constantly even such a small percentage of the total could only be told by a much greater number of cases; but the percentages of other elements are probably correct within a small amount. It is interesting to notice that only one of the fourteen fish had enjoyed such a mixed diet that no element predominated in its food.

The considerable part played by the mollusks and insect larvæ, both of which are strictly bottom forms, shows that the common whitefish is to a large extent a bottom feeder. This view is strengthened by the down pointed sucker-like mouth of the fish as well as by the presence in the stomachs of numbers of small stones, which were undoubtedly snapped up with some morsel of food.

Of the six specimens of the long jaw (*C. prognathus*), which furnished stomach contents sufficiently undigested to be estimated, five contained *Mysis relicta*, constituting respectively 95, 95, 95, 98 and 100% of the total mass, or an average of 97%, while in the sixth *Pontoporeia Hoyi* was equally abundant. No other recognizable object was present in any of the fish examined. Smith (94, p. 10), in his description of this new species, is able to give only conjectural information as to its food. The stomachs examined do not bear out his surmise that "its larger mouth and more powerful jaws indicate a somewhat wider range of food than is possessed by the common whitefish." Nor do I think that such is the case; its deeper habitat favors a more simple diet since the fauna of the region is more limited in number of species. Again, the anatomical characters referred to find their explanation equally well in the hunting habits of the fish; its food is captured in motion and not on the bottom, hence the strictly bottom forms in the food of the common whitefish, the mollusks and insect larvæ, as well as those accidental inclosures, algæ and stones, are entirely wanting. This difference in the mode of life of the fish, which seems to me adequately indicated by the facts given, is of importance in another connection, as will be seen later.

Only two specimens of the blackfin afforded identifiable stomach contents; *Mysis relicta* was here 95 and 99% of the total amount; one of these specimens yielded a single individual of *Diaptomus* sp., whose presence was perhaps accidental; otherwise nothing was recognized.

Collections of parasites were made from all the species of whitefish obtained at Charlevoix; occasionally individuals were found badly infested with a species of *Echinorhynchus*, but as a whole these fish were very free from parasitic infection.

The question of the decrease of the true whitefish has attracted much attention during the last ten or fifteen years, and the cause has been a matter of considerable dispute. I believe we are in position to offer positive evidence on the question. The fact of the large decrease in the whitefish catch since 1880 is, I think, unquestioned at present, although there is evidence of yearly fluctuations in the catch both before and since that time. The present scarcity of the fish may be due (1) to disease, (2) to scarcity in food supply, (3) to migration, (4) to the crowding out or supplanting of the true whitefish by some other species, (5) to over catching. The first may be dismissed without further discussion since any disease widespread enough to cause such a result would surely have come to the notice of fishermen.

The three most important elements of the whitefish food are *Pontoporeia*, *Mysis*, and the small mollusks. At nearly all of the stations where hauls were made with the vertical plankton net (see Pl. V) the dredges and other nets were also used. Among their contents the three forms just mentioned were the most common of all objects; so much so indeed that their absence in rare cases was noteworthy. Thus, for example, in my notebook is entered for station ix: "Dredge out 5 minutes. Noteworthy—*Mysis* wanting, mollusks almost, very few *Pontoporeia*; according to Capt. O'Neil this point (middle of w. side reef) has *no* whitefish." The immediate food of the whitefish is present at nearly all points and in large quantities, hence the decrease in whitefish supply can hardly be due to this cause. So far as migration is concerned, it might be invoked to explain a deficiency in the catch in a single locality, but statistics now at hand show the decrease to be general and not confined to a single region.

In his recent paper Smith (94, p. 11) suggests an interesting theory as to the possible cause of the disappearance of the common whitefish; namely, that it has been crowded out by the long jaws. It is a well known biological fact that in the struggle for existence one species is supplanted by another more favored form which takes possession of its home and food supply and literally crowds it out of existence. This is most likely to occur between closely related forms in circumscribed areas, and it would appear at first thought as if this were a very probable instance of such supplanting. It is also a curious fact that the same idea occurred to me in Charlevoix and was discussed with at least one member of the party, Mr. Bryant Walker, before the appearance of Smith's paper. In the course of further study, however, I became convinced that the idea was untenable and that the competition between the two species was more apparent than real; in other words that this could not be the cause of the diminishing whitefish supply. The reasons for this conclusion may be given briefly. In the first place the range of the two fish is radically different; long jaws are rare at twelve fathoms where the best catches of whitefish are made, and conversely whitefish are not found at the depth of twenty to twenty-five fathoms where the long jaws are most abundant; nor could I find evidence of any change in range of the species during the last twenty-five years, if one will accept the testimony of the best fishermen. Again, the food of the two forms is somewhat different, as noted above, and more still the place and manner of feeding I have already pointed out that the whitefish is probably a bottom feeder, and that the long jaw is not, but obtains its food more probably free in the water. Furthermore, if crowding out were the cause, the grounds formerly occupied by whitefish must now be preempted by long jaws. It can be positively stated, I think, that such is not the case. As is noted elsewhere in connection with the plankton studies, we examined especially those regions which had been good whitefish grounds, but now yielded little or no catch. In all of the places whitefish food was plentiful, though the grounds were now practically deserted by *all* fish, and many of them were much too shallow for long jaws.

The apparent coming in of the long jaw and the increase in its catch are really due to very different causes. The failure of the shallow whitefish grounds forced the fishermen little by little to move their nets into deeper waters and so gradually to increase their catch first by the addition of long jaws and then by the still deeper living blackfin. These two species are only apparently new arrivals, and their supposed increase at the time of the whitefish decrease is due merely to changed methods of fishing. In this connection it is interesting to notice the testimony of Capt. John O'Neil of Charlevoix, that the long jaws themselves are less frequent in Traverse Bay than formerly, that they are smaller in size and more scattered.

We are thus forced to the conclusion that the decrease in the whitefish supply can have no other cause than overcatching. This is not the place to discuss good and bad methods of fishing or remedies for the trouble. Our investigations point unmistakably to the cause of the depletion in the whitefish supply; it is the removal from the lakes of a larger number than can be replaced by natural processes and than has been successfully returned by artificial hatching. Greater results from the latter methods depend upon a better knowledge of exact conditions in the lakes, and to aid in this has been the object of our studies.

SOURCE OF FOOD SUPPLY.

The question as to the food of the whitefish and the amount of the supply at any point, or, expressed in other terms, the actual fish supporting power of any region is not determined by a single element. The number of *Mysis* and *Pontoporeia* in any given area does not determine the fitness of that region for raising whitefish.

Not only must the present supply of whitefish food be large, but the region must be capable of maintaining the supply constant in spite of the inroads made by the fish, else the food would soon be exhausted and the fish starved to death. The further test must be then made as to the capacity of the place to furnish these food animals with sufficient nourishment for rapid multiplication. Thus we are taken back step by step through the entire series of biological interdependence to the primitive food supply, which must always be plant life, since that alone has the power to manufacture living matter out of the simpler substances taken from earth, air and water. It is then clear that the entire series of biological relations must be worked out, and with each step will come new light on the subject.

The question of the source of the food of the lake fish brings us to consider first in brief the peculiar characters of these bodies of water in comparison especially with the inland lakes. On the more extended trips into Lake Michigan, which were undertaken with a view to obtaining evidence on the distribution of life in the lake, the contrast between this and an inland lake, or even Lake St. Clair, became very apparent. The most striking peculiarity was the entire absence, in the part of the lake examined, of the larger plants. The shore plants and rushes which in Lake St. Clair formed several distinct zones (Pieters, 94) along the margin of the lake, were either entirely absent or present in rare instances. The shallow part along shore, or lake terrace (Reighard, 94, p. 13) is very narrow at this point and subject to considerable change by the frequent storms; to this is due no doubt the absence of shore vegetation, and there are out in the lake, beyond the shore terrace, no areas shallow enough to permit the growth of such vegetation. Not only were the littoral zones bare of plants but the bottom also. The fields of *Chara* which carpeted the bottom of Lake St. Clair so densely that Reighard (p. 15) compares them to a thrifty field of clover, were almost never found. Only once in the sheltered High Island harbor was there a shallow area covered in this way with *Chara.* Elsewhere stretches of bare sand alternated with equally bare rocky bottoms or with areas of huge cobblestones. The stones brought up in the dredge were frequently covered with a film of a pale greenish tinge, which under the microscope appeared to be made up of myriads of minute unicellular algæ. Rarely one found a few threads of *Cladophora* or other filamentous alga, but aside from these insignificant exceptions *no fixed plants.* The rich variety of forms, worms, crustaceans, mollusks and insect larvæ, dredged from the *Chara* beds of Lake St. Clair, were entirely lacking. In their place the dredge yielded in many regions a considerable number of specimens, belonging, however, only to a few genera. The *Mysis* and *Pontoporeia*, though taken from near the bottom undoubtedly obtain their food mostly from the water and are not properly bottom feeding forms. The Lamellibranchs are dependent upon the same source of food supply; but the Gastropods and a few species of insect larvæ, almost entire Chironomids, are true bottom forms. They live either on the microscopic plants or on decaying matter which has fallen from the superjacent water. Wherever fixed plants were found there was no dearth of life. The *Chara* beds found at High Island harbor were as rich in life as those of Lake St. Clair. Mr. Walker mentions in his report (Appendix V), the extraordinary number of species of mollusks obtained there from a single haul of the trawl.

It should be mentioned here that the *Chara* beds do not in themselves afford nourishment directly to any fish, or so far as I can find to any abundant animal; and hence their absence does not directly reduce the food supply. Indirectly, it affects the conditions very materially; for the beds afford shelter to myriads of small bottom forms, crustaceans, insect larvæ, and worms, which find food in the microscopic plants growing among them. Hence they are breeding beds for fish food and furnish the best of conditions for the development of bottom feeding fish. Lake Michigan does not furnish in this region a sufficient variety of bottom food for many species of bottom fish. The few forms which are found are all included in the menu of the whitefish; they seem, however, so far as our observation went, to be widely distributed and to be present each in considerable numbers.

Some of the physical characteristics of the lake, though less striking at first, are equally important. That part of the lake which lies above the ten fathom line (18.3 meters) forms but a very narrow border on the map; yet this is more than three times the greatest depth observed in Lake St. Clair. The extreme depth reached in our work was 130 meters, which is just the average for the entire lake, and not quite two-thirds of the extreme depth. The considerable depth of most of the lakes involves very different conditions of life in the greater part of the waters from those which exist in a shallow lake. Perhaps the most important is temperature. On different days the surface temperature ([1]) of the lake varied from 16.7° to 19.4° C. (62° to 67° F.). The bottom temperature was always less than the top and in twenty to twenty-five meters was only 10° to 6.4° C. (50° to 43.5° F.) while at the deepest stations (112 and 130 m.) the thermometer registered only 4.2° C. (39.5° F.) on the bottom. In general it appears that near the surface the fall in temperature is more rapid for the same amount of descent than near the bottom; there were however, curious variations in bottom temperature at about the same depth, *e. g.* 14.4° C. at 22 meters, Station xxi, and 6.4° C. at 24 m,, Station ii, which show wide departure from the general principle of equal temperature at equal depths, owing perhaps to local conditions. Our observations are not extended enough to throw light upon special cases. The whole of the lake in this region below the limit of 25 m. from the surface has a temperature of 7.5° C. (45.5° F.), or less, which is about 11° C. (20° F.) lower than the surface temperature, while the water below 110 to 130 m. does not rise above 4° C (39.2° F.), which is the temperature of maximum density for fresh water. Here temperature conditions are probably uniform the year through, while at the surface they are subject to the greatest fluctuations.

In the next place the amount of light decreases rapidly with the depth, and yet not so rapidly here as in ordinary lakes Since the amount of inflow is small in proportion to the total volume of the lake, and since the shallow area where the water can become roily in time of storm is very limited, the water contains extremely little inorganic matter in suspension, and hence the northern lakes are noted for their transparency. In the Charlevoix region the water is beautifully clear and allows objects to be discerned at considerable depths. We made no tests to determine the relative transparency of the water, but its evident superiority in this respect compensates for the great depth to a large extent by permitting the passage of a much larger amount of light, and hence the development of plant life in deeper strata of the water. Again, the disturbance in time of storm does not extend very far from the surface. The ten fathom line lies far below wave action and thus the greater portion of the water is undisturbed by storms.

Furthermore, the pressure increases with the depth. At about 10 m. the pressure is twice that at the surface (one atmosphere, 15 lb. sq. in.); at 103 m., all forms are subjected to a pressure of 11 atmospheres. Yet the animals brought up from this depth seemed to suffer no inconvenience by their rapid transit from a pressure of 165 lbs. to the square inch to one of only 15 lbs. to the square inch.

Finally, the lake is free from such currents as exist in Lake St. Clair. The slow movements of the water in definite directions are not at all comparable with the stream of a river, and the limited inflow and outflow, already discussed in this report, serve to maintain the lake in a condition of stable equilibrium.

The factors just discussed are of the greatest importance in determining the character of the food supply in the lake, as well as its distribution. But it should first be noted that the question of food supply here is totally unlike similar questions in agriculture and the difference is fundamental in its character. The land animals which furnish the large part of man's food supply are herbivorous. Their supply of food is drawn from the great group of grasses, grains and forage plants, which growing before our eyes, derive nourishment from the inorganic materials in earth, air and water. There intervenes but a single step from the inorganic to the organic and the chain of biological relations is short and simple in the main. It is not only capable of immediate observation, but it has also been in all its details the subject of long continued and careful study in numerous experiment stations of the country. The preparation and the enrichment of the soil, the development of the seed, the growth of the plant, the diseases which threaten it, the enemies which attack or crowd it out, its protection and improvement have been for many years the care of trained minds on experimental fields and in well equipped laboratories. How different the case for the fish culturist! In many instances he does not even know the immediate food of the species in question. Observations on its habits and life history are all too scanty and experimentation limited and uncontrolled.

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[1] See table of plankton hauls on pages 32 to 35.

The series of biological relations are also widely different from those on the land. In fresh water there are few large plants; in the Great Lakes a still scantier amount. Among all the food fish there are none that depend on these plants for food supply; they are purely carnivorous. One of the most fundamental questions for the fish culturist is then clearly the source of food supply in the Great Lakes and the steps in the process of its transformation into fish flesh. Directly connected with this are the questions of its amount and distribution since fish culture is evidently depedent for success and development upon these factors. Unless the primitive food supply be abundant at the present time, all efforts to increase the number of fish will fail of ultimate success; unless the food of the fry is found in sufficient quantities in that locality where the fry are planted, the maximum number can never reach the adult condition; and finally the possible increase in the fish supply is limited by the amount and distribution of the food in so far as those factors are themselves beyond the control of the fish culturist.

The limited inflow of Lake Michigan renders the amount of food supplied to its waters from this source comparatively insignificant and, moreover, it is almost entirely inorganic matter which is received in this way. The limited shore areas and general lack of shore plants make the shore washings an equally unimportant source of food supply, although from it as from the preceding source would be received a certain amount of inorganic material in solution and in suspension. The occasional fields of *Chara* and other bottom algæ add only a limited amount of food, but the scanty development of this bottom flora, already commented upon, precludes the possibility of considering it more than a secondary source of food supply.

From the atmosphere is leached out by every rain much valuable inorganic matter, and the winds bring from time to time insects, both singly and in swarms, which fall a ready prey to the fish of the water. But even this is a secondary and incidental source; the biological relations of the life in the water are not seriously affected by this addition. No sufficient source of primitive organic food material can be found external to the lake; it must be sought *within the water itself.* It must also be capable of forming the inorganic material into living matter, and since we have already seen that of the green plants which possess this power, the larger fixed forms are lacking or present in entirely insufficient quantities, it is clear that the source whatever it may be must escape notice by virtue of the minute size of its individual elements, since the abundance of the material as a whole must necessarily be presupposed.

If one draws through the water a net of finest gauze and collects its gleanings into a small glass, there will be seen a myriad of minute forms almost or quite invisible to the eye. The mass of material obtained depends not only upon the length of the haul and size of the net, but upon numerous other conditions as well. Under no probable circumstances, however, will the net fail to collect a certain amount of material which the microscope shows to be composed of living organisms of varied character. Among these are both plants and animals, the latter so insignificant that their own motion does not suffice to carry them over any considerable distance, and hence both plants and animals are dependent upon waves, currents and winds for their wide distribution. Their entire existence is passed floating freely in the water and both plants and animals possess characters of form or structure fitting them for maintaining their position. Very many are provided with long processes, enabling them to present greater surface to the water; others have oil drops reducing their specific gravity. This mass of living forms is known as the *plankton*, and it plays such an important part in the economy of the water that the relations may briefly be outlined here. One may justly call it the *primitive food supply* of the water, and as such it is of course the origin of fish food.

The smallest forms in the plankton are the one-celled plants and animals, and the first are really the actual[*] source of the food supply. They float, as it were, in a sort of broth, or nutritive fluid, the water containing in solution those simple inorganic substances which they are enabled by the possession of green matter (chlorophyll or some related substance) and in the presence of light to transform into living protoplasm. The well known principle that rapidity of chemical action depends upon the proportion of surface to volume, was long ago used by Leuckart to explain the extraordinary growth of these unicellular plants.[†] In them the proportion of surface to volume is far greater than in any larger forms; the production of protoplasm, that is growth, goes on with extreme rapidity and the simple process of reproduction by division which characterizes them, results in the production of many generations within a limited period of time. These unicellular plants are the food not only of the unicellular animals, but also of some of the higher forms, and it is on their extraordinary power of multiplication that the entire economy of the water depends in last analysis.

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[*] There is a large group of doubtful forms, frequently classed as animals among the flagellate protozoans; they contain chlorophyll, or some allied substance, and by virtue of this are enabled to make use of inorganic food material like the green plants. These forms, which are abundantly represented in the plankton, are classed by other authorities as plants. If the latter classification be accepted, the statement made above is exactly true; if, however, these forms are regarded as animals, there must be a minor exception recorded against the statement that the simple plants are the *only* actual source of the food supply. This is a matter both undecided and secondary at most and needs no further explanation here; it is mentioned only to avoid danger of misunderstanding the statements made in the text. In any event the primitive source of food supply is found exclusively within the unicellular forms of the plankton.

[†] Zacharias (95, p. 108) calls attention to the growth of these algæ as more rapid than that of the higher plants, such as rye, and finds in this evidence that "the living organic substance of which the contents of the *Melonia* threads are made must be much more easily formed anew than that of the rye." This is evidently a false conclusion; the rapidity of growth is not due to any theoretical ease of formation of the substance in question, but is clearly traceable *to the greater proportion of surface to volume*, and hence greater possibility of chemical activity, and secondly to *the total immersion of the growing body in the nutritive fluid* In the higher plants it is also true that a considerable amount of energy must be devoted to the differentiation of organs for supplying all parts equally with nourishment. In the simpler algæ, *Melonia* in the case cited above, all parts are alike active and growing.

In the plankton are contained, however, in addition to the unicellular plants and animals already mentioned, the Rotifera and many Crustacea. Other forms seemed to be either rare or entirely wanting in the plankton taken at Charlevoix, but a more exact enumeration of the species encountered in this region may be found in the introduction and in the appendices to this report. These four elements together constitute the food supply of the lake. The unicellular plants, or Protophyta, are dependent upon inorganic nourishment; the Protozoa subsist upon these plants and both form the food of the Rotifera, while the Crustacea feed upon anything which falls in their way. The last group forms the predominating element in the plankton, constituting in almost all instances the greater portion of any haul, and they are the immediate source of food for the lake fish. The fry depend directly upon the Crustacea of the plankton and rarely also the adult draws its nourishment from the same source, as in the case of the lake herring. More frequently it is through the medium of some larger form or forms. Thus the lake trout is piscivorous and feeds upon the herring and smaller forms. Of the whitefish food, already discussed and described, each species is dependent entirely upon the plankton, living or dead and sunk to the bottom, except the univalves, which also draw a portion of their nourishment from the fixed microscopic plants of the bottom. Reighard has given (p. 24) a table showing the interdependence of the various forms of life in a fresh water lake; it includes shore and bottom forms as well as the plankton.

It was apparent soon after the work of Charlevoix began that in general the plankton did not contain as many species as in Lake St. Clair, but the total mass per volume of water proved considerably greater. This was due to the greater number of individuals of a species present. Especially striking was this in the case of the small Crustacea, for often a bottom tow made in Round Lake was so thick as to deserve the name of "crustacean soup," and yet it consisted almost entirely of a single species of Copepod. The catch recalled hauls taken in the ocean in respect to total amount of material, but was far from possessing the rich variety of forms characteristic of marine tows. Not only did none of the hauls from Round Lake show the great number of species recorded in occasional tows on Lake St. Clair, but the average haul was decidedly inferior in this respect to the average haul from the latter place. In spite of this it was regularly true that the total amount of plankton in the average haul from Round Lake was considerably greater than the total amount obtained in average hauls from Lake St. Clair. The same feature became apparent during work in Pine Lake and Lake Michigan at a later date; the plankton in these lakes contains only a limited number of species present in a large number of individuals.

QUANTITATIVE PLANKTON WORK.

Since the plankton plays such a fundamental part in the life of the water, in being the primitive food supply, some guide to the fertility of the lake will be given by ascertaining as exactly as possible its amount and its distribution, both vertically into zones and horizontally into areas if such exist. The determination of fluctuations in amount and quality with weather and seasons is of equal importance; but our observations extended over too limited a period to permit of obtaining evidence on these points. The work of the summer throws some light on the questions of amount and distribution in the Charlevoix region, important not only in themselves, but for comparison with the data derived from similar experiments in Lake St. Clair during the previous year. Our experiments on these points were made in the course of the last two weeks of August, those of Reighard in Lake St. Clair during the second week of September. They are probably sufficiently identical in time that direct comparisons may be drawn between the figures without the danger that we are dealing with results which represent conditions of different seasons of the year. This precaution in treating the results is necessary since both Apstein and Zacharias have shown the existence in various European lakes at least of a considerable seasonable variation, both in the amount and in the quality of the plankton.

The apparatus used in these determinations was the modified vertical net described by Reighard (p. 26-29) and the process followed in the management of the net and the treatment of the material obtained was almost identical. Slight modifications introduced by the writer were successful enough to warrant mention in this place. The plankton holders made by cutting off the bottom of a short 6 dr. homeopathic vial and annealing the edges, as used in 1893, had some slight disadvantages. Apart from the waste of time and bottles in making a supply of perfect tubes, it was difficult to tie the gauze over the bottom so securely that it would not come off under some circumstances, and the mouth of the bottle was so small as to render it wearisome to change the fluids on account of the tardiness of the filtering in case the enclosed mass of plankton was at all large. In view of these two difficulties, I had Whitall, Tatum & Co. make some plankton tubes after my model. The tubes were pieces of $\frac{7}{8}$ inch glass tubing 3 inches long, with a carefully constructed flange at each end which turned outwards about one-sixteenth inch. It was found that the flare increased the filtering surface sufficiently to aid greatly in the passage of fluids and that the gauze could be tied over the end with great security and rapidity. We had occasion to preserve 11 or 12 cc. in a single tube, but in spite of the mass had no difficulty at all in filtering the water out and in getting various fluids through the tube. The flange was also of material assistance in tying the second gauze to close the tube; this was frequently done when the boat was rocking violently and in no case did we lose any of the contents of the tube. In transferring from one fluid to another a syringe bulb with a fine glass tube pipette was used to force air into the tube through one gauze end and thus render more rapid the passage of the fluid through the other gauze from the tube. I feared at first that in spite of the No. 20 silk gauze used for covering the ends of the tubes there might be some small loss of plankton on account of the pressure which could be exerted by the bulb, or at least some damage done to delicate forms; but after experimenting we could detect no loss in the washings nor damage to the most delicate forms in the plankton and hence adopted this method in all our subsequent work. These two trivial modifications mean a saving in time for each tube of plankton put up of at least twenty per cent, and much more where the amount of plankton is exceptionally large.

Between the eleventh and twenty-ninth of August eight days were spent with the fishing tug "Minnie Warren" in making stations at various points in the Charlevoix region. In all twenty-six stations were made, two in Round Lake, six in Pine Lake, and eighteen in Lake Michigan. The stations, which are indicated in order by Roman numerals on the map of the region appended to this report, were made chiefly on fishing grounds of past or present value, and in the selection of these we had the assistance of Capt. John O'Neil of the "Minnie Warren," an old and successful fisherman of Charlevoix. In addition to the stations on fishing grounds some few were made in adjacent waters, either very shallow or very deep, in order to obtain material for the comparison of the various places. It is thought that these stations represent very fairly the different conditions which prevail in this region and afford then some idea of its character as a whole.

At each station the depth of the water and temperature of the water at bottom as well as at the surface and of the air were first taken with the sounding machine and thermometers lent by the United States Fish Commission. The condition of surface, of sky and weather were also noted and the exact position and character of the place recorded. A series of hauls with the vertical net was made at 2, 5, 10, 25, 50, 100 meters and bottom, the length of the series depending each time on the depth of the water. The contents of the net at each haul were preserved in a plankton tube of the character already described and provided with a label bearing the number of the station and haul. Further details of the process may be found in Professor Reighard's report (p. 27, 28). In this way a total of one hundred tubes of plankton were obtained.

In the table of plankton hauls (p. 32–4) it will be noticed that the depth of the water and the depth of the haul do not bear any constant relation to each other. This is due to the different methods employed in obtaining each. The depth of the water was recorded by the sounding machine, as already described, while the depth of the haul was measured on the rope of the vertical net which was marked off by meters so that the distance from the upper ring of the cone of the net to the surface of the water could be determined directly. In this way the distance through which the net was hauled could be measured without danger of error from the slight slant of the net rope or from inequalities of the bottom. This method of obtaining the depth of the haul was used for all stations after the first three (I to III^3 inclusive).

After the vertical hauls were finished, the anchor was lifted and two or more of the dredges as well as bottom and top tow nets were used to ascertain the character of the bottom and the quality of the life in the water at this place. The tows were examined by various members of the party after the return to the laboratory and the results of the examination entered on the regular blanks. This gave an approximate idea of the composition of the plankton from any station, as well as of the bottom fauna and flora. Various circumstances interfered with carrying out this plan in full at all stations. However dredgings were made in the majority of cases, including one at station xi from a depth of 112 m., but at the deepest station, 130 m., the dredge was not used.

For the determination of the quantity I used the tubes of plankton collected at the various stations and preserved as described above. The contents of each were carefully transferred to a glass cylinder or measuring tube graduated to tenths of a cubic centimeter and were allowed to settle exactly twenty-four hours. The volume was then taken and recorded. This volume is only an approximation of the amount of the plankton since the latter is very light and will settle for days if left undisturbed. It will naturally settle more quickly if shaken occasionally, and the degree of concentration it reaches depends very clearly on the character of the material in this particular plankton haul. Finally the mass

Conditions of— Time, 1894. Month.	Time, 1894. Day.	Time, 1894. Hour.	Haul. Serial number.	Haul. Place.	Haul. Character.	Haul. Depth from which drawn.	Haul. Velocity in meters per second.	Bottom.	Water. Depth in meters.	Water. Temperature in degrees Centigrade. Bottom.	Water. Temperature in degrees Centigrade. Top.	Water. Surface.	Water. Current.	Air. Temperature in degrees Centigrade.	Air. Wind direction and strength.	Air. Sky.	Volume of plankton in cubic centimeters. Taken in vertical net.	Volume of plankton in cubic centimeters. Calculated, using mean velocity 0.61 m. per second. Under 1 sq. meter of surface.	Volume of plankton in cubic centimeters. Calculated, using mean velocity 0.61 m. per second. Per cubic meter of water.
Aug.	11	10:30 A. M.	I	Lake Michigan	B	107.8	.60		108.22	5.1	18.9	Slightly rough			S W, 3	Hazy	9.74	176.29	1.64
"	11	12:30 P. M.	II		B	24.1	.58		24.52	6.4	18.3	"			S W, 3	"	5.08	91.95	3.82
"	11	12:50 "	II^a		B	24.1	.42		24.52	6.4	18.3	Nearly smooth			S W, 2	Light rain	4.20	76.02	3.2
"	11	3:45 "	III		B	50.5	.61		50.92	5.6	16.7	"			S, 1	Hazy	7.52	136.11	2.70
"	11	4:00 "	III^2		S	10	.77		50.92	5.6	16.7	"			S, 1	"	3.15	57.02	5.70
"	11	4:10 "	III^3		S	3	.75		50.92	5.6	16.7	"			S, 1	"	2.50	45.25	15.08
"	11	5:05 "	IV		B	35	.32		36.78	5.8	17.8	"			S, 1	"	9.50	171.95	4.91
"	15	10:30 A. M.	V	Pine Lake	B	22	.63		20.74	13.1	18.9	Light waves		14.8	N, 3	Cloudy	3.50	63.35	2.88
"	15	10:40 "	V^2		S	15	.71		20.74	13.1	18.9	"		14.8	N, 3	"	3.26	59.01	3.93
"	15	10:50 "	V^3		S	10	.50		20.74	13.1	18.9	"		14.8	N, 3	"	2.44	44.16	4.42
"	15	11:00 "	V^4		S	5	.50		20.74	13.1	18.9	"		14.8	N, 3	"	1.61	29.14	5.83
"	15	11:30 "	V^5		S	2	.40		20.74	13.1	18.9	"		14.8	N, 3	"	1.32	23.89	11.95
"	15	12:00 M.	VI		B	30	.56		33.01	10.4	20	Little smoother		14.4	N, 3	"	3.78	68.42	2.28
"	15	12:15 P. M.	VI^2		S	15	.60		33.01	10.4	20	"		14.4	N, 3	"	3.35	60.64	4.04
"	15	12:30 "	VI^3		S	5	.50		33.01	10.4	20	"		14.4	N, 3	"	2.35	42.54	8.51
"	15	12:45 "	VI^4		S	2	.50		33.01	10.4	20	"		14.4	N, 3	"	1.27	22.99	11.5
"	15	2:00 "	VII		B	30	.59	Yellow marl	33.01	10.6	18.6	Few white caps			N N W, 3	Clearing	5.20	94.12	3.14
"	15	2:30 "	VII^2		S	15	.63	"	33.01	10.6	18.6	" "			N N W, 3	"	3.79	68.6	4.51
"	15	2:35 "	VII^3		S	10	.71	"	33.01	10.6	18.6	" "			N N W, 3	"	3.13	56.65	5.67
"	15	2:45 "	VII^4		S	5	.56	"	33.01	10.6	18.6	" "			N N W, 3	"	3.00	54.3	10.86
"	15	3:00 "	VII^5		S	2	.50	"	33.01	10.6	18.6	" "			N N W, 3	"	1.68	30.41	15.20
"	15	3:45 "	VIII		B	11	.58	Marl	11.32	20	21.1	White caps		18.1	N N W, 4	Clear	3.55	64.26	5.84
"	15	4:00 "	VIII^a		B	11	.69	"	11.32	20	21.1	"		18.1	N N W, 4	"	3.20	57.92	5.27
"	16	9:20 A. M.	IX	Lake Michigan	S	2	.67	Sand	28.29	10	18.3	Slight swell		13.3	N W, 2	"	1.07	19.37	9.68
"	16	9:30 "	IX^2		S	5	.68	"	28.29	10	18.3	"		13.3	N W, 2	"	2.25	40.73	8.15
"	16	9:40 "	IX^3		S	10	.59	"	28.29	10	18.3	"		13.3	N W, 2	"	3.02	54.66	5.47
"	16	9:55 "	IX^4		S	25	.51	"	28.29	10	18.3	"		13.3	N W, 2	"	6.48	117.29	4.69
"	16	10:15 "	IX^5		B	26	.52	"	28.29	10	18.3	"		13.3	N W, 2	"	6.41	116.02	4.46
"	16	11:30 "	X		S	2	.57	"	55.93	5.2	18.3	Smoother		15.6	N W, 1	"	1.02	18.46	9.23
"	16	11:40 "	X^2		S	5	.56	"	55.93	5.2	18.3	"		15.6	N W, 1	"	1.45	26.25	5.25
"	16	11:50 "	X^3		S	10	.59	"	55.93	5.2	18.3	"		15.6	N W, 1	"	2.64	47.78	4.78

"	16	12:05 P. M.	X4	Lake Michigan	S	25	.54	"	55.93	5.2	18.3	"		15.6	N W, 1	"	5.85	96.84	3.87
"	16	12:20 "	X5		B	53	.59	"	55.93	5.2	18.3	"		15.6	N W, 1	"	5.90	106.79	2.01
"	16	1:50 "	XI		S	2	.57	Sand & debris	112	4.2	18.3	Rippled only		16.7	S, 1	"	1.22	22.08	11.04
"	16	1:58 "	XI2		S	5	.71	" "	112	4.2	18.3	" "		16.7	S, 1	"	1.95	35.30	7.06
"	16	2:05 "	XI3		S	10	.39	" "	112	4.2	18.3	" "		16.7	S, 1	"	3.68	66.61	6.66
"	16	2:25 "	XI4		S	25	.69	" "	112	4.2	18.3	" "		16.7	S, 1	"	6.38	115.48	4.62
"	16	2:45 "	XI5		S	50	.75	" "	112	4.2	18.3	" "		16.7	S, 1	"	8.72	157.83	3.16
"	16	3:00 "	XI6		B	112	.75	" "	112	4.2	18.3	" "		16.7	S, 1	"	9.41	170.32	1.52
"	16	4:05 "	XII		S	2	.57	Sand	5.66	18.3	18.3	" "		16.7	S, 1	"	1.48	26.79	13.39
"	16	4:15 "	XII2		B	4.3	.67	"	5.66	18.3	18.3	" "		16.7	S, 1	"	1.35	24.44	5.68
"	16	5:10 "	XIII		S	2	.57	"	32.06	7.5	18.3	" "		16 7	S W, 1	"	1.57	28.42	14.21
"	16	5:20 "	XIII2		S	5	.83	"	32.06	7.5	18.3	" "		16.7	S W, 1	"	2.30	41.63	8.33
"	16	5:30 "	XIII3		S	10	.63	"	32.06	7.5	18.3	" "		16.7	S W, 1	"	4.40	79.64	7.96
"	16	5:40 "	XIII4		S	25	.78	"	32.06	7.5	18.3	" "		16.7	S W, 1	"	9.35	169.24	6.77
"	16	5:55 "	XIII5		B	30	.75	"	32.06	7.5	18.3	" "		16.7	S W, 1	"	7.91	143.17	4.77
"	17	12:00 M.	XIV		B	8	.47	"				Rough			Terrific squall	Low clouds	3.61	65.34	8.16
"	18	9:00 A. M.	XV		S	2	.40	Mud & Chara	11.32	16.7	17.2	White caps		18.9	N E, 4	Cloudy	1.4	25.34	12.67
"	18	9:10 "	XV2		S	5	.59	" "	11.32	16.7	17.2	"		18.9	N E, 4	"	1.72	31.13	6.23
"	18	9:20 "	XV3		B	10	.63	" "	11.32	16.7	17.2	"		18.9	N E, 4	"	2.95	53.40	5.34
"	18	12:15 P. M.	XVI		S	2	.57	Sandy mud	22.63	7.2	17.5	Few white caps		16.7	N, 3	Clearing	1.50	27.15	13.58
"	18	12:25 "	XVI2		S	5	.67	"	22.63	7.2	17.5	" "		16.7	N, 3	"	2.34	42.85	8.47
"	18	12:35 "	XVI3		S	10	.77	"	22.63	7.2	17.5	" "		16.7	N, 3	"	4.47	80.91	8.09
"	18	12:45 "	XVI4		B	23.5	.57	"	22.63	7.2	17.5	" "		16.7	N, 3	"	6.98	126.34	5.38
"	18	4:30 "	XVII		S	2	.50		132.66	4.2	18.3	White caps rare		18.9	N b E, 3	Scattered cl'ds	1.29	23.35	11.67
"	18	4:35 "	XVII2		S	5	.59		132.66	4.2	18.3	" "		18.9	N b E, 3	" "	2.45	44.35	8.87
"	18	4:42 "	XVII3		S	10	.61		132.66	4.2	18.3	" "		18.9	N b E, 3	" "	4.90	88.69	8.87
"	18	4:50 "	XVII4		S	25	.57		132.66	4.2	18.3	" "		18.9	N b E, 3	" "	8.80	159.28	6.37
"	18	5:00 "	XVII5		S	50	.56		132.66	4.2	18.3	" "		18.9	N b E, 3	" "	9.90	179.19	3.58
"	18	5:20 "	XVII6		S	100	.54		132.66	4.2	18.3	" "		18.9	N b E, 3	" "	9.28	167.97	1.68
"	18	5:50 "	XVII7		B	130	.52		132.66	4.2	18.3	" "		18.9	N b E, 3	" "	8.86	160.37	1.23
"	22	3:30 "	XVIII		S	2	.57	Sand	36.78	6.4	19.4	Slight swell		21.7	W S W, 1		1.45	26.25	13.12
"	22	3:40 "	XVIII2		S	5	.63	"	36.78	6.4	19.4	"		21.7	W S W, 1		1.86	33.67	6.73
"	22	3:50 "	XVIII3		S	10	.65	"	36.78	6.4	19.4	"		21.7	W S W, 1		2.72	49.23	4.92
"	22	4:00 "	XVIII4		S	25	.58	"	36.78	6.4	19.4	"		21.7	W S W, 1		4.98	90.14	3.61
"	22	4:10 "	XVIII5		B	36	.57	"	36.78	6.4	19.4	"		21.7	W S W, 1		4.95	89.60	2.49
"	25	11:05 A. M.	XIX		S	2	.44	Sandy, shells	35.83	7.5	18.9	Few white caps	*	21.9	N, 3		1.42	25.70	12.85
"	25	11:15 "	XIX2		S	5	.56	" "	35.83	7.5	18.9	" "	*	21.9	N, 3		1.93	34.93	6.99
"	25	11:28 "	XIX3		S	10	.54	" "	35.83	7.5	18.9	" "	*	21.9	N, 3		3.25	58.83	5.88
"	25	11:35 "	XIX4		S	25	.64	" "	35.83	7.5	18.9	" "	*	21.9	N, 3		6.55	118.56	4.74
"	25	11:45 "	XIX5		B	36	.58	" "	35.83	7.5	18.9	" "	*	21.9	N, 3		11.90	215.39	*5.98
"	25	1:10 P. M.	XX		S	2	.44	Smooth sand	39.6	7.5	19.4	Rippled			S W, 1		1.02	18.46	9.23
"	25	1:15 "	XX2		S	5	.59	" "	39.6	7.5	19.4	"			S W, 1		1.75	31.68	6.34
"	25	1:25 "	XX3		S	10	.65	" "	39.6	7.5	19.4	"			S W, 1		2.74	49.59	4.96
"	25	1:35 "	XX4		S	25	.64	" "	39.6	7.5	19.4	"			S W, 1		4.58	82.9	3.32
"	25	1:45 "	XX5		B	41	.59	" "	39.6	7.5	19.4	"			S W, 1		6.08	110.05	2.68

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* For discussion of this haul see pages 38 and 45. The figures are given in the table without correction.

Conditions of—																	Volume of plankton in cubic centimeters.		
Time, 1894.			Haul.					Bottom.	Water.					Air.			Taken in vertical net.	Calculated, using mean velocity 0.61 m. per second.	
Month.	Day.	Hour.	Serial number.	Place.	Character.	Depth from which drawn.	Velocity in meters per second.		Depth in meters.	Temperature in degrees Centigrade. Bottom.	Temperature in degrees Centigrade. Top.	Surface.	Current.	Temperature in degrees Centigrade.	Wind—direction and strength.	Sky.		Under 1 sq. meter of surface.	Per cubic meter of water.
Aug.	25	2:00 P. M.	XXI	Lake Michigan	S	2	.44		22.63	14.4	19.4	Rippled	--	24.2	N, 2		1.28	23.17	11.58
"	25	2:08 "	XXI2		S	5	.59		22.63	14.4	19.4	"	--	24.2	N, 2		1.94	35.11	7.02
"	25	2:15 "	XXI3		S	10	.63		22.63	14.4	19.4	"	--	24.2	N, 2		2.78	50.32	5.03
"	25	2:22 "	XXI4		B	22	.79		22.63	14.4	19.4	"	--	24.2	N, 2		4.90	88.69	4.03
"	25	3:20 "	XXII		S	2	.57	Mud	43.38	7.2	19.4	Rough	--	20	N, 2		.98	17.74	8.87
"	25	3:25 "	XXII2		S	5	.56	"	43.38	7.2	19.4	"	--	20	N, 2		1.38	24.98	5.00
"	25	3:33 "	XXII3		S	10	.65	"	43.38	7.2	19.4	"	--	20	N, 2		2.73	49.41	4.94
"	25	3:40 "	XXII4		S	25	.60	"	43.38	7.2	19.4	"	--	20	N, 2		4.19	75.84	3.03
"	25	3:50 "	XXII5		B	42	.71	"	43.38	7.2	19.4	"	--	20	N, 2		5.60	101.36	2.41
"	29	3:00 "	XXIII	Round Lake	S	2	.57	Marl	18.86	18.1	18.3	Light swell	--	16.1	N, 5	Cloudy	1.62	29.32	14.66
"	29	3:05 "	XXIII2		S	5	.67	"	18.86	18.1	18.3	"	--	16.1	N, 5	"	1.85	33.49	6.7
"	29	3:10 "	XXIII3		S	10	.54	"	18.86	18.1	18.3	"	--	16.1	N, 5	"	2.51	45.43	4.54
"	29	3:15 "	XXIII4		B	17.5	.67	"	18.86	18.1	18.3	"	--	16.1	N, 5	"	3.83	69.32	3.96
"	29	3:30 "	XXIV		S	2	.67	"	6.6	18.3	18.3	Rippled	--	16.1	N, 5	"	1.60	28.96	14.48
"	29	3:35 "	XXIV2		B	4	.57	"	6.6	18.3	18.3	"	--	16.1	N, 5	"	1.52	27.51	6.88
"	29	4:15 "	XXV	Pine Lake.	S	2	.67	Blue marl	15.09	13.1	16.1	Rough	--	16.7	N, 5	Clearing	1 20	21.72	10.86
"	29	4:20 "	XXV2		S	5	.83	" "	15.09	13.1	16.1	"	--	16.7	N, 5	"	1.88	34.03	6.81
"	29	4:25 "	XXV3		S	10	.87	" "	15.09	13.1	16.1	"	--	16.7	N, 5	"	3.10	56.11	5.61
"	29	4:30 "	XXV4		B	15	.83	" "	15.09	13.1	16.1	"	--	16.7	N, 5	"	2.63	47.60	3.17
"	29	4:45 "	XXVI		S	2	.67	Marl	21.69	11.1	16.1	Little rough	--	18.3	N, 4	"	1.41	25.52	12.76
"	29	4:50 "	XXVI2		S	5	.71	"	21.69	11.1	16.1	"	--	18.3	N, 4	"	1.49	26.97	5.39
"	29	5:00 "	XXVI3		S	10	.77	"	21.69	11.1	16.1	"	--	18.3	N, 4	"	2.6	47.06	4.71
"	29	5:10 "	XXVI4		B	21	.62	"	21.69	11.1	16.1	"	--	18.3	N, 4	"	2.71	49.05	2.34

obtained depends to some extent upon the diameter of the measuring tube in which the settling is done, as I ascertained in the course of some experiments on this matter. These experiments are discussed in full in another paper, and it is sufficient to note here that the volumes entered in the table were measured in the same tubes and as exactly as possible under the same conditions as those recorded by Reighard for Lake St. Clair. The results, then, are directly comparable with those he gives (p. 29, 30), and are also an approximate measure of the amount of plankton in these waters. The volumes obtained are entered in the table of plankton hauls given here (pp. 32–4.)

These volumes are relative to the size of the net; and as was first shown by Hensen (87) and as is explained also by Reighard (p. 28), for general use it is necessary to apply a total correction in order to find the amount of plankton under one square meter of surface. In this way are eliminated the special features due to the size of the individual net employed and the filtering power of the material used in its construction. In the first place, the net opening has not an area of one square meter and in the second place the resistance of the stuff forces some water aside, so that the net does not filter the entire column of water through which it passes. The area of the net opening is 1,237.86 sq. cm., so the correction for the area is 8.08. Hensen has given a table of corrections for varying velocities also, and these were used by Reighard, though the uncertainty of the method by which they were calculated was discussed in an appendix (p. 57) to his report. In some cases Reighard was forced to adopt a correction for an average velocity since that for the observed velocity was such as to make the result an absurdity. Similar cases occurred in my own calculations as for instance at station IV, where the amount of plankton per cubic meter of water was more for the entire depth than any station furnished in the surface statum, and as will be shown later, this stratum contains always more than any other of similar thickness. I, therefore, calculated the amounts on the basis both of the observed velocity and of the average velocity, and plotted the results in a manner to be explained later. It was at once evident on the examination of the plot that the lines were practically coincident except in a few cases, and in half of these the results based upon observed velocity were evidently false. I therefore decided to use a correction of 18.10 based upon an average velocity of 0.61 m. per second and a net opening of $\frac{1}{8.08}$ sq. m. And the amounts under each square meter of surface as given in the table are obtained by multiplying the volume of plankton taken by this average correction of 18.10. The results in the corresponding column of Reighard's table were obtained by using the actual correction according to Hensen's method save in the few instances noted. My adoption of an average correction was influenced not only by the facts above but also by some other considerations. In the first place a physicist, who at my request made a very careful examination of Hensen's method of approximations, gave it as his opinion that the physical principles involved would not hold good for velocities at either extreme, if indeed they were correct for mean velocities. In the next place, it is difficult to observe the *exact* time of a haul and the error in observation, which is of course increased by movements of the boat or by irregularities of the surface of the water, is proportionally very much greater for the shallower strata. Finally in comparing results of Reighard, and myself, it will be possible to see whether the the deductions made hold good under both circumstances, that is are really general principles, or whether they are modified in any way by the method of calculation employed.

The volume per cubic meter of water as given in the table is obtained by dividing the volume under one square meter of surface by the depth of haul. Other details of the table are self explanatory. The hauls at stations I to IV inclusive were made on the first day and were somewhat experimental; they differ from the others in method of handling and preserving, and have not the same series of strata in depth; they are hence discarded in the study of strata. The hauls at XIV* were interrupted by a terrific squall and hence this is also omitted in the same connection.

A brief consideration of the question will show that the errors in the method employed are all in one direction and tend constantly to reduce the real amount, to make the final result less than the quantity actually present in the water. Although carefully guarded against, the loss of minute quantities by accident or in the course of the numerous manipulations undoubtedly does take place. Pauses however slight, or unequal velocities in movement during the raising of the net, failure of the gauze to filter as rapidly as usual owing to clogging or to some other cause, reduce the amount of water filtered by the net and hence also the amount of plankton obtained below that actually present in the column. Finally some forms, good swimmers, will escape the net as it is hauled up; this error is evidently less with our net, having an opening of 1,238 sq. cm. in area than with the nets used in European lakes by Zacharias and Apstein in which the area of the opening did not exceed 64 to 100 sq. cm.

This method does not, then, give absolute exactitude, nor can I see why that would be more desirable if possible. The variations in the amount of plankton present are greater far than the errors of the method, as already illustrated, and the approximation obtained by this method is sufficiently near for practical purposes. Certainly it is true that, since all errors tend only to reduce the actual amount, *the volume of plankton present is not less than the figures given in the table.* A single exception must be made in those cases when foreign matter is accidentally included in the net but these are easily detected by microscopic examination of the mass.

From Lake Michigan in the Charlevoix region eighteen bottom hauls show the following results in total amount of plankton obtained:

Number of Station	I.	II.	III.	IV.	IX.	X.	XI.	XII.	XIII.	XIV.	XV.	XVI.	XVII.	XVIII.	XX.	XXI.	XXII.	Av.
Volume of Plankton in cubic centimeters per cubic meter of water	1.64	3.82 3.20	2.70	4.91	4.46	2.01	1.52	5.68	4.77	8.16	5.34	5.38	1.23	2.49	2.68	4.03	2.41	3.69

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* Stations will be denoted hereafter by a Roman numeral only.

In Round and Pine lakes, which have immediate and free connection with Lake Michigan at Charlevoix, the amounts obtained in nine bottom hauls were as follows:

Number of Station	V.	VI.	VII.	VIII.	XXIII.	XXIV.	XXV.	XXVI.	Av.
Volume of Plankton in cubic centimeters per cubic meter of water	2.88	2.28	3.14	5.84 5.27	3.96	6.88	3.17	2.34	3.97

Twenty-seven bottom hauls were made in Lake St. Clair in 1893, two at each station except the first, with the following results (Reighard 94, p. 31):

Number of Station	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.	XIII.	XIV.	XV.	XVI.	Av.
Volume of Plankton in cubic centimeters per cubic meter of water	4.97	1.44	2.76	2.01	2.74	2.29	3.69	2.70	2.54	4.15	4.79	3.60	1.80	1.90	3.03
	----	2.68	3.89	2.01	3.62	3.08	3.69	3.01	2.39	4.15	3.97	3.31	2.42	2.33	----

The total average for all Lake Michigan stations is 3.69 cc. of plankton per cubic meter of water. In Lake St. Clair the total average was 3.03 cc. per cubic meter of water. But the stations in Lake St. Clair varied in depth from 1.5 to 5.6 meters, while Lake Michigan hauls extended from 4 to 130 m., so that the comparison should be made with corresponding hauls of the latter only, and these have an average of 6.39 cc. or more than double the amount of the St. Clair hauls. The tabulation of results (Pl. I and III) afford a graphic presentation of these relations. *Lake St. Clair contains only half as much plankton per cubic meter of water as is taken from water of equal depth in Lake Michigan at Charlevoix.*

Reighard records (p. 37) the average of four bottom hauls made in Lake Erie in 1893, as 8.98 cc. per cubic meter of water. If compared with the hauls of corresponding depth in Lake Michigan they are evidently richer, and that by forty per cent. Reighard notes, however, the peculiar location and richness of the two stations at which the four hauls were made and mentions a third station with a different location and a much smaller volume of plankton. Including this haul also, the average of all the Lake Erie stations is 7.41 cc. of plankton per cubic meter of water, which is nearly one-sixth more than the average of stations of equal depth on Lake Michigan at Charlevoix. The number of observations is too small to permit of a positive statement, but it seems probable that there is somewhat more plankton per cubic meter of water in the western end of Lake Erie than in water of equal depth in Lake Michigan near Charlevoix.

In comparison with the volumes for European lakes, given by Apstein (94), Lake Michigan in the Charlevoix region is decidedly "plankton poor." Thus, in September, Great Plöner See, which is a typical "plankton poor" lake, contains, for a depth of 40 meters, 5 cc. of plankton per cubic meter of water. In Lake Michigan, two hauls of almost the same depth, XX and XXII, averaged only 2.55 cc. of plankton per cubic meter of water, or about one-half as much. And yet this small amount which is present constitutes *in toto* a tremendous mass. The estimated volume of Lake Michigan is about 7,500,000 millions of cubic meters, and if the average of the lake contains an amount of plankton per cubic meter of water equal only to the lowest amount for any bottom haul of the Charlevoix region (1.23 cc. at XVII^7), the total mass of plankton in the entire lake would equal *more than nine and one-third millions of cubic meters.* This deepest haul, XVII^7, was made at about the average depth of the lake and hence may well be taken as a representative haul for the lake, especially since, as the chart shows (Pl. I), this haul does not depart appreciably from the normal line of relative volumes—to be discussed later.

It is valuable to consider for a moment what actual amount of food is contained in this volume of plankton. For this purpose two masses of plankton, XIII^4 and XIX^4 were selected as average hauls, and XIX^5 as an instance of a haul which was evidently much polluted by foreign matter. The plankton was shaken up in a limited quantity of alcohol and a certain portion of the mixture removed, weighed, air-dried and weighed again. The weight of the same sample was also taken when dried to a constant weight at 100° C. and after calcining the ash was weighed. The ash was then digested in concentrated hydrochloric acid, washed, dried and weighed to obtain the approximate amount of sand present.* The plankton which remained after the removal of the small portion treated in the manner just described, was measured by the volumetric method and from this the exact portion removed was calculated from the original volume of the plankton. These results are expressed in the following table:

Number of haul.	Depth in meters of—		Volume in cc.		Percentage of original volume used.	Weight in milligrams.			
	Haul.	Water.	Original volume of haul.	Volume measured after removal of part.		Air dried sample.	Sample dried to constant weight at 100° C.	Ash in sample.	Silicious matter in sample.
XIII^4	25	32	9.35	4.88	47.8	53	50	7.6	2.3
XIX^4	25	36	6.55	1.00	84.7	61	57	8.	2.1
XIX^5	36	35	11.90	9.61	19.2	207	206	160.	112.

From these data may be obtained by simple calculation the following table in which figures are given to the nearest whole number:

Number of haul.	Percentage in air dried sample of—				Weight in milligrams for entire haul of—			Weight in grams of plankton under 1 sq. m. of surface.	
	Organic.	Entire ash.	Ash, not sand.	Sand.	Air dried.	Ash.	Sand.	Air dried.	Ash.
XIII^4	85.7	14.3	10.7	3.6	111	16	4.8	2.0091	0.2896
XIX^4	86.8	13.2	9.8	3.4	72	9	2.5	1.3032	0.1629
XIX^5	22.6	77.4	23.2	54.2	1077	833	583	19.5118	15.0773

A microscopical examination of XIII^4 and XIX^4 shows that they are very nearly pure plankton. We may then from the average of these two estimate that such plankton contains about 3.5 per cent of silicious material, 10 per cent of other earthy substances, largely calcareous, and 86 per cent of organic substance. The first element is entirely useless as food and the second somewhat so, but the third consists almost wholly of nutritive matter. From this somewhat rough calculation it may be seen that the plankton contains almost wholly matter useful as food and that the percentage of useless matter is very small.

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* These processes were very kindly carried out for me in the chemical laboratory of the University of Nebraska, by Mr. E. E. Nicholson, to whom my sincere thanks are due.

Comparing these figures with those from XIX[5] it appears that there is in the latter haul an excess of 50 per cent in sand and 64 per cent in total inorganic matter. This represents foreign matter included in that haul and yet not all since there was also organic matter stirred up from the bottom in the haul and 75 per cent is a low estimate of the total foreign substance; this would make the actual volume about 7.5 cc. A more detailed description of the process and of its value in plankton studies may be found in another paper (Ward, 96[a]).

Hensen (87, p. 34) has made some determinations of the percentage of the various elements in oceanic plankton, with the following results for fresh plankton hauls, which were drained nearly dry and then subjected to quantitative analysis. These hauls were composed largely of diatoms and contained also a certain unknown amount of sea water:

Organic matter	42.1	25.5	39.6
Soluble salts	7.3	43.8	17.3
Insoluble salts	50.6	30.7	43.1

The large percentage of soluble salts is undoubtedly due, in part at least, to the salt of the sea water, but even after the elimination of that factor, it will be seen that the lake plankton is very much richer in organic material, that is, in actual food matter. Some analyses of single species given by Hensen approach more nearly to the results obtained for the lake plankton. Thus *Mysis*, analyzed after drying, contained 89.6% of organic and 10.4% of inorganic matter; for *Salpa* the percentages were 85.4 and 14.6. and for other species similar results were obtained. From this it appears that the lake plankton is much more nearly pure food material than the marine plankton, having not far from the same proportion of organic matter that is contained in the more favorable forms from the ocean.

The total amount of plankton in the lake may also be estimated from the average volume of the two normal hauls XIII[4] and XIX[4]. Both hauls are from a depth of 25 m. and as will be shown this distance includes the great bulk of the plankton. The small amount below this limit will more than balance the deficiency in such limited areas as are less than 25 meters in depth. Under 1 sq. m. of surface at a depth of 25 m. these hauls show 1.5 to 2 g. of plankton, which amounts to 15 to 20 kg. to the hectare. The total area of Lake Michigan is about six million hectares or six hundred square myriameters. A weight of plankton equal to 15 to 20 kg. to the hectare becomes 150,000 to 200,000 kg., or 150 to 200 metric tons to the square myriameter, or for the entire lake a mass of six hundred times that quantity, making the total weight of plankton in Lake Michigan not less than 90,000 to 120,000 metric tons.* Unless there is a much larger amount of plankton in the Charlevoix region than in other parts of the lake, a condition not at all likely, this estimate is conservative and falls below the true amount, since in it was discarded all the plankton lying below the 25 meter line. It is true that below this limit there may not be a large quantity to the cubic meter, yet the enormous area of the lake and the considerable depth below that limit would make even a small factor important on the whole. The table on page 50 shows that nearly half of this is contained in the surface stratum of two meters in thickness; or, expressed in terms of the actual amount, the surface two meters of Lake Michigan contains from 40,000 to 60,000 metric tons of plankton.

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*A metric ton is almost exactly equal to the English "long ton."

This calculation may be verified by a second computation, made on a different basis. As shown above, Lake Michigan is estimated to contain about 9,300,000 cubic meters of plankton. From the table given on page 38, it appears that 1 cc. of plankton weighs about .011 to .012 g., or 1 cubic meter would weigh 11 to 12 kg. The total mass of plankton in the lake, 9,300,000 cu. m., would on this basis weigh from 102,300,000 to 118,600,000 kg. or 102,300 to 118,600 metric tons. The close agreement in the results reached by this and the preceding method is evidence of the correctness of the approximation.

From these data it is easy to estimate the amount of plankton found under each acre of surface. Thus, 15 to 20 kg. to the hectare would equal 12 to 16 lb. per acre of surface. In comparing this with the production of the land it is necessary to consider the very high proportion of organic matter present here. Hensen (87, p. 96) has made a similar calculation for the ocean on the basis of the sum total of increment in the plankton from haul to haul; thus in a dozen periods having a total length of 228 days, the sum of all the increments in the plankton was 4,162 ccm.; an average of 18 ccm. per day, which in the course of the year would equal 6,570 ccm., and on the basis of analysis would contain 15-17 g. of organic material. The destruction of food matter by the Copepoda he had previously calculated at 133 g. yearly; hence the total yearly production must be at least 150 g. per square meter of surface. The estimated production of a similar area in grain would be 180 g. of dry organic matter, so that the water is little if any inferior and the consideration of other factors may easily show its productivity to be greater than that of the land.

More recently Zacharias (95, p. 107) has essayed a similar estimate on the basis of a single element, the increase in the amount of *Melosira* which reached within 29 days the sum of 1,500 kg. per hectare, or 1,200 lb. per acre.

From comparison of these figures with those of the fertility of the land, as measured by various crops, these authors are inclined to believe the productivity of the water equal to that of the land, or even slightly greater than it. There are, however, certain sources of error, especially in the latter comparison, which materially influence the result. In the first place the comparison is made by both authors with land in a high state of cultivation, whereas, the water is as yet untouched by like processes of stimulation. But more than this, the land which is taken as the basis for comparison, is protected from inroads and the entire product of its fertility stored up for future use. In the case of the water, the plankton is subject to daily and hourly diminution, one form devouring another until the material is finally carried beyond the reach of all calculations. The periodic increase in the volume of the plankton takes place in spite of the constant drain on its mass; and even were there no increase at any time, it is clearly evident that there must be active growth to keep the volume constant. To measure this growth, or to arrive at an approximate idea of the fertility of the water is, I think, beyond the limit of present possibilities. More data with reference to the continuous consumption of the plankton than those afforded by a single group must be obtained before we can estimate its ratio of growth. But least of all can the productivity of the water be measured by the abnormal increase of a single factor in the plankton. One thing is certain the productivity of the water is great enough to keep the food supply intact against all inroads made thus far. When the first European settlers reached this region they found the waters of the lakes teeming with fish. At least an equal number could thrive now in these waters.

DISTRIBUTION OF THE PLANKTON.

The distribution of the mass of food material is of the greatest moment for the fish culturist and the existence of variations in the quantity deserves careful investigation. There are in fact several problems here. The plankton may be equally or unequally distributed at various times of the year; independent of such seasonal variations there may be also variations in the amount found in different parts of the lake, the horizontal or areal distribution, and finally at any given time of year and point in the lake the plankton present may be unequally distributed in various levels of the water The last question, that of vertical distribution, may be subject to modification during the course of twenty-four hours as a result of periodic migration or of passive change in level on the part of the various components of the plankton. Each of these questions will be discussed in the light of the investigations made at Charlevoix.

It is evident that only long continued observations in any region can throw light on the first question, that of seasonal distribution. Thus far the only information on the yearly variations of the plankton in any locality comes from a paper by Apstein (92) in which is given the yearly curve of plankton volumes for Gross Plöner See in Holstein. This shows a rapid increase through August and September to the maximum which falls near the beginning of October and an equally rapid decrease from that time through November. The minimum occurs in February but the decrease to it and increase from it are gradual. It would be venturesome to hold that the seasonal variation in Lake Michigan was the same, yet a similar increase in amount with the rising temperature of the water and decrease with lowering of the same is altogether probable. If this be so our observations were made during the time in which the volume of plankton was approaching its maximum.

If long extended observations are necessary for the determination of seasonal variations, the reverse is true in the investigation of horizontal or areal distribution. In order to avoid the progressive yearly variations in the mass of plankton those observations which are to be used for comparison in determining horizontal and vertical distribution must be made within a limited time. It is evident then that the series of hauls made in Lake St. Clair and in Lake Michigan are peculiarly fitted for the discussion of these questions since each series fell within a limit of ten days; and since both were made at almost exactly the same season of the year they may safely be compared with each other also. The results possess great strength as scientific evidence since they are deduced not from single isolated experiments, in which error or chance may play a promiment part, but are based upon systematic observations numerous enough to eliminate chance and to show whatever errors may inhere in the methods employed. This cannot be too strongly emphasized in the light of a growing tendency to discover principles and to corroborate the work of other investigators on the evidence afforded by a single experiment!

The first element which may be considered in its effect on areal distribution is depth. The hauls made in the Charlevoix region are well fitted to afford evidence on this question since they cover very wide conditions in respect to depth. Omitting those few hauls which have already been set aside as experimental or failing to agree in some important particular with the others, the remainder may be grouped in four classes; the first three include those made in Lake Michigan and the fourth those from Round and Pine lakes. Class A includes Lake Michigan hauls made in water from 4 to 12 meters deep; B those from a depth of 20 to 42 meters and C comprises those hauls from water whose depth varies between 50 and 130 meters while in D are grouped all those made in Round and Pine lakes where the water was 4 to 30 meters deep. The hauls under D are not sufficiently numerous for subdivision although they evidently correspond to those of both A and B in Lake Michigan.

		Total No.
A.	Shallow hauls in Lake Michigan include XII, (XIV),* XV.	6
B.	Medium " " " " " (II, IV,) IX, XIII, XVI, XVIII, XIX, XX, XXI, XXII	41
C.	Deep hauls in Lake Michigan include (I, III,) X, XI, XVII	22
D.	Hauls in smaller lakes include V, VI, VII, (VIII), XXIII, XXIV, XXV, XXVI	30
	Total number of hauls made	99

If for the various bottom hauls the total amounts of plankton obtained are brought together and then averaged for the separate groups, we have the following:

A. No. of Station	XII.	XIV.	XV.	Average.
Total volume in cc. of plankton obtained	1.35	3.61	2.95	2.64

B. No. of Station	II.	IV.	IX.	XIII.	XVI.	XVIII.	XIX.	XX.	XXI.	XXII.	Av.
Total volume in cc. of plankton obtained	5.08 4.20	9.50	6.41	7.91	6.98	4.95	? 11.90 **	6.08	4.90	5.60	6.16

C. Number of Station	I.	III.	X.	XI.	XVII.	Av.
Total volume in cc. of plankton obtained	9.74	7.52	5.90	9.41	8.86	8.29

Considering then the Lake Michigan stations alone it is evident that at least to the limit of our experiments, *the total amount of plankton increases with the depth of the water.* The average amount for all stations in Lake Michigan is obtained from the total average of the three tables, and reaches 6.16 cc., being curiously the same as the average amount for stations of medium depth. For comparison the table of total amounts for class D is given here.

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* Those in parenthesis are not available for the study of the various strata.

** Omitted in the average for reasons given on page 45.

D. Number of Station	V.	VI.	VII.	VIII.	XXIII.	XXIV.	XXV.	XXVI.	Av.
Total volume in cc. of plankton obtained	3.50	3.78	5.20	3.55 3.20	3.83	1.52	2.63	2.71	3.32

It must be remembered that Group D includes stations of all depths in Pine and Round lakes and ought to be compared with the sum of A and B rather than with any one or all of the Lake Michigan groups. From this it would appear that the total amount of plankton is somewhat smaller in Pine and Round lakes than it is in adjacent waters of Lake Michigan.

From Reighard's table of plankton hauls (pp. 29, 30) the average amount taken in all bottom hauls in Lake St. Clair is found to be only 0.63 cc. and for the four bottom hauls taken in Lake Erie 2.98 cc. It is difficult to compare these amounts correctly with each other or with the results given above, since the depth is different at each station; and there is furthermore no basis for comparison with the results obtained by other investigators with a vertical net of a different size. If, however, instead of taking the total amount of plankton obtained in each bottom haul, we compare the amount per cubic meter of water as found for each bottom haul by calculation and entered in the last column of the table, close comparisons can then be made between the different hauls. This is done in the following tables:

A. Number of Station	XII.	XIV.	XV.	Av.
Amount of plankton in cc. per cu. m. of water	5.68	8.16	5.34	6.39

B. Number of Station	II.	IV.	IX.	XIII.	XVI.	XVIII.	XIX	XX.	XXI	XXII.	Av.
Amount of plankton in cc. per cu. m. of water	3.82 3.20	4.91	4.46	4.77	5.38	2.49	5.98 *	2.68	4.03	2.41	3.82

C. Number of Station	I.	III.	X.	XI.	XVII.	Av.
Amount of plankton in cc. per cu. m. of water	1.64	2.70	2 01	1.52	1.23	1.82

D. Number of Station	V.	VI.	VII.	VIII.	XXIII.	XXIV.	XXV.	XXVI.	Av.
Amount of plankton in cc. per cu. m. of water	2.88	2.28	3.14	5.84 5.27	3.96	6.88	3.17	2.34	3.98

From these tables it appears that the volume of plankton per cubic meter of water is greatest at the shallower stations, and least at the deepest stations while the medium hauls retain a mean position with reference to the others. Before comparing the stations in class D it should be noted that there may be taken two sets of hauls corresponding to groups A and B; the first consists of VIII and XXIV, hauls having a depth of 4 to 11 meters, and agrees almost exactly with the limits of class A (4 to 12 m.) while the hauls V, VI, VII, XXVI from depths of 21 to 30m. correspond closely to the shallower half of class B. Hauls XXIII and XXV come between the two and are set aside for the moment. The average volume of plankton per cubic meter of water is for the first set 6 cc., a trifle less than the average of hauls in class A, and for the second set it is only 2.66 cc. which is much less than the average for class B. It should be noted also that the hauls correspond only to those in the shallower half of class B and this should have the greater amount of plankton per cubic meter of water if the principle just stated, namely, the decrease in amount of plankton per cubic meter of water with increase in depth of the water, holds true of the stations in general as it has already been shown to obtain in the artificial groups A, B, and C. And in fact the average for those stations in class B having a depth between 22 and 30 meters is 4.18 cc. which is nearly sixty per cent greater than the average amount from the stations of equal depth in Pine Lake. This seems to show first, that the average amount of plankton per cubic meter of water is somewhat less in Round Lake and in the shallow part of Pine Lake than in corresponding depths of Lake Michigan; and secondly that in the deeper portion of Pine Lake the amount of plankton per cubic meter of water is very much less than at stations of equal depth in Lake Michigan.

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* Not averaged; see pages 38 and 45.

Comparisons simply by figures such as the preceding are somewhat unsatisfactory in that they can not ordinarily be kept in mind or arranged in such a way that their interrelation becomes perfectly clear. So, for instance, in the sets of tables just given (pp. 42 and 43) it was shown that the total volume of plankton increases with the depth but the volume per cubic meter of water decreases under the same circumstances. This was clear as between the three artificial series of hauls, A, B, and C, of which averages were given. But the question is naturally suggested as to whether it also holds true of the terms of the series and to what extent it is regular or periodical. In other words, are the increase in total volume of plankton and the decrease in volume per cubic meter of water comparatively constant, or does one find sudden changes at certain points. It was in the course of studies upon these questions that I hit upon a method of representation which shows these relations most clearly and unmistakably.

If common "cross-section paper" of suitable size and ruling be employed and if the vertical lines be taken to represent stations and the horizontal lines distances or amounts, a line may be drawn connecting the various points denoting the depth of each haul, and this may be called the line of depths. Similarly, by connecting points, indicating the total volume of plankton obtained in a bottom haul at each station, a line of total volumes is obtained and in a like manner a line of volumes per cubic meter of water. The position of the lines will then indicate clearly the relations between the factors of depth, total volume and volume per cubic meter of water. This has been done for all the bottom hauls in Lake Michigan (Pl. I), which are arranged in order of depth so that the line of depth (D) turns continuously in one direction from the shallowest haul (XII) at one side of the plate to the deepest (XVII) at the other. The course of this line of total volumes (T) is not entirely in the single direction, but there are numerous retrogressive variations, the most marked of which is that made at the vertical XIX. This was a noticeable point in the first rough draft of the plate, and I set at once to work in order to find, if possible, the cause of such an irregularity, for, when there could be found no mistake in the calculation, the idea of a swarm came up at once since such an abrupt increase and decrease in comparison with the antecedant and the subsequent haul of nearly equal depth must have been due to the localized massing of the plankton, in full or in part, or to something foreign. It proved to be the latter; for in my field notes was entered against this haul (XIX^5) "full of sand,(current?), probably poor for measuring," and at the time of measuring this tube of plankton I noted opposite the amount, "too much sand, throw out." By approximation from the hauls of (XVIII) and (XX), which agree closely in time, place, and general conditions, as well as in amounts at other depths, I judged the amount of true plankton to be about 7.5 cc. instead of 11.90 cc. as measured and entered in the table.* This haul is more fully discussed elsewhere in connection with the vertical distribution of the plankton. I have hence drawn a dotted line to indicate more nearly the true relation of the plankton for XIX. As far as the other variations are concerned, they are not sufficient to change or even mask the relation of this line of total volumes to the depth, and hence they may be passed here. It may be that they are due to a cause similar to that in the case just explained, but less in amount, or to errors in the instruments or methods employed, or finally to actual small variations from the normal in the amount of plankton in a certain place.

So far as the general tendency of this line (T) is concerned it agreed with the line of depth but shows also an individual variation. During the first part of its course it indicates a uniform increase in the total volume more rapid than the increase in depth; after a depth of about thirty meters has been attained, however, its direction is variable and uncertain until the sudden change in depth between X and XI where it marks an increase less decided than that in the depth. The slight decrease at XVII would be an equally slight increase were the amount for the haul of 50 meters at this station substituted for that from the bottom; that is the amount of plankton is approximately equal at the two stations XI and XVII. The relations between the depth and the total amount of plankton present may be summarized as follows: Up to about thirty meters of depth the amount of plankton found in the lake increases more rapidly than the depth, but beyond fifty meters decidedly less rapidly. Further experiments are necessary to determine whether there is comparative uniformity in amount or a slight increase for depths beyond one hundred meters.

The third line on this plate (R) joins points on the verticals of the various stations, indicating by their distances from the upper margin the amount of plankton in cubic centimeters per cubic meter of water, as shown in the last column of the table (pp. 32–34). In contrast to the line of total volumes last considered it may be called the line of relative volumes. It will at once be clear that it follows the opposite direction from the line of total volumes and shows a decided decrease from the shallower stations to the deeper. It is also most irregular in the first half of its course and there also departs most from the dotted line of averages which is almost coincident with it near the end. This is undoubtedly due in large part to the greater influence on the amount per cubic meter which is exerted by errors in the capture of the material or in measurement later, since the divisor, the depth of the water, is a smaller number for the shallower stations. An error of measurement for instance causes a greater departure from the normal when distributed over only eight meters of depth than when divided among fifty to one hundred meters.

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* Almost exactly the same result was reached by a more complicated method; see p. 38.

In the next place it is evident that local conditions influence most strongly the shallower stations. Some are sheltered by projecting shores or are on wide areas of shallow water where the temperature is higher than in a more exposed situation. Currents or winds may also accumulate plankton at such points or may reduce the average amount somewhat. All of these agencies are less likely to act unequally in the freer open waters. At some of the shore stations, which show the greatest variations from the average a current could be noticed but it was difficult on account of the wind and the roughness of the water to determine without special instruments which were not at our command, its direction and strength. The dotted line which is a part of the line of relative volumes is thought to indicate closely the average amount of plankton per cubic meter of water and the irregularities of the solid line (R) show then the variations from that average. It will be noticed that no variation is equal to one-third of the relative volume and that most of them are very much less than that. The extreme deflection at XIX is of course due to the same cause as that in the line of total volumes and the dotted line from XVIII to XX indicates a correction on the same basis as that already discussed for the line of total volumes.

It may be noticed that some stations are omitted from the chart. They are those mentioned on page 42 at which, owing to various causes, a series of hauls was not made and which on that account cannot be used in the following tables and in the discussion of the vertical distribution of the plankton. They are therefore omitted here also in order that the various charts may be capable of being exactly compared. If included, the lines on the chart would not have been materially altered.

The following conclusions may then be drawn from these studies as to the amount of plankton in Lake Michigan in the Charlevoix region.

I. The total volume increases with the depth, but more rapidly for depths up to about thirty meters than beyond that point.

II. The volume per cubic meter of water decreases as the water grows deeper. This decrease is irregular for the shallower stations, but comparatively constant in deeper water.

III. No variation is large enough to warrant the assumption of the existence of alternate densely crowded and barren areas in the water, i. e. of masses or "swarms" of the plankton as a whole.

On plate I^B are plotted the same lines for the stations, in Pine and Round lakes. A glance will suffice to show that the same conclusions may be drawn here also, the total volume of plankton obtained in the bottom hauls increases comparatively regularly with the depth and with approximately equal rapidity for all depths reached. However, all stations made, and in fact the extreme depth of the lake, fall within the thirty meter limit which was seen to be about the termination of the rapid increase in the total volume of plankton in Lake Michigan. The amount per cubic meter of water as shown by the line of relative volumes (R) decreases very rapidly in the shallower regions but remains comparatively constant for hauls of twenty meters or more. The numbers of hauls in Round and Pine lakes is rather small to use as the basis of general conclusions on the distribution of the plankton in these waters, but so far as they go they show exactly similar conditions to those prevailing in Lake Michigan.

In the comparison, which should be made only with the part of I^A lying to the left of the vertical XIII, however, it is noticeable that both the line of total volumes and that of relative volumes fall above the corresponding lines for stations of equal depth in Lake Michigan. With the exception of those at the shallowest station *all hauls in the smaller lakes show both absolutely and relatively less plankton than was taken in hauls of the same depth from Lake Michigan.*

I have taken from the table given in Reighard's report corresponding data on the depth, the total and relative volumes of the plankton for Lake St. Clair and have plotted them in a similar manner (Pl. III). The line of total volumes (T) increases slightly but with striking uniformity from the shallowest to the deepest station and throughout its course closely parallels the line of depth (D). The line of relative volumes (R) is somewhat irregular, especially at the shallower stations. A general tendency in its course is not pronounced but it certainly does not show a decrease with increase in depth. In other words the total amount of plankton per cubic meter of water, taken in bottom hauls in Lake St. Clair, seems to be nearly if not quite independent of the depth of the water.

The explanation of the apparent contradiction between this and the distribution of the plankton in the northern lakes as described above, is to be found in the widely different conditions which obtain in the two places. Only one station in Lake Michigan came within the limits of the deepest of the sixteen bottom hauls in Lake St. Clair. The meagre depth of the latter region is accompanied by minimal diferences in the temperature of the water at the top and bottom, 1° C. being the greatest difference recorded. In the next place the considerable inflow and outflow cause rapid exchange and continual mixing of the water at all levels and make Lake St. Clair merely an expansion in the course of a river. It is as such subject to widely different influences which yield results naturally unlike those that obtain in the deep and stable waters of the northern lakes.

In one respect the chart of hauls from Lake St. Clair affords even more decided evidence than those of Lake Michigan and Pine Lake. There is no difference considerable enough to warrant the assumption of the existence of swarms of the plankton as a whole.

The question of temperature was carefully studied but I was unable to detect any relation between the volume or variations of the plankton and the temperatures recorded at the various stations. I was also unsuccessful in discovering other factors which affect the areal distribution of the mass and am inclined to think that in the St. Clair and Charlevoix regions at least depth is the only prominent factor influencing the horizontal distribution of the entire mass of the plankton.

The entire discussion thus far has been based upon a study of the various bottom hauls, but there was made also at each station a series of partial hauls. The comparison of these partial hauls with each other and with the bottom hauls show some particulars with reference to the vertical distribution of the plankton as a whole which deserve consideration here. In the course of correspondence with Professor Reighard during the past year, he sent me a synopsis of the possibilities in the case which seems of much value in its bearings on the question under consideration as to warrant its reproduction here.

"The following conditions are possible with regard to the distribution of plankton in a body of water.

I. *The plankton may be uniformly distributed through the whole volume of water.* This condition is thought not to exist in nature.

II. *The plankton is unequally distributed, and the water may be divided into artificial strata* in which

- A. *The volume of plankton per cubic meter of water is unequal for different strata of equal thickness but*
  - 1. *Equal for different parts of the same stratum.*—This is the condition to be expected from the nature of the environment which in so far as it is not influenced by currents, may be said to vary with the depth but to remain constant throughout any thin horizontal stratum. It is the condition defended by Apstein and would yield in all parts of a lake equal volumes for equal depths, whether hauls extended to the bottom or not.
  - 2. *Unequal for different parts of the same stratum;* in this case there are two possible groups of cases.
    - a. The inequalities of the strata may be so arranged as to compensate each other in such manner that in vertical columns of water of equal dimensions extending from the bottom to the surface there will always exist equal volumes of plankton in different parts of the lake. This would result from II. A. 1. in case migrations of large numbers of individuals occurred only vertically. This condition would yield equal volumes for equal *bottom* hauls but unequal volumes for some other equal hauls.
    - b. Or arranged without reference to each other so that vertical columns of water of equal dimensions and extending from surface to bottom will usually contain unequal volumes of plankton in different parts of the lake. This would result from I. or II. A. 1, by migration of masses of individuals horizontally or obliquely. Such migrating masses may produce local accumulations of any conceivable form or size, such as spheres, sheets extending horizontally or vertically, etc. They are thus capable of producing a wide range of variation in the volume of the plankton from bottom and other hauls.

The migrating masses may consist of all the species existing in the plankton and in the proportions in which they exist there—in which case the resulting local accumulations may be called *plankton swarms*; or they may consist of one or several species and might be called *species swarms*. Species swarms occurring in such way as to compensate one another would remain undetected by the volumetric method."

The work of the first day with the vertical net was experimental, and does not show any uniformity in the number or depth of the various hauls at each station, as given in the table, page 32. They cannot be used for this reason in the comparative study of the strata. In all hauls thereafter we distinguished a number of artificial strata as follows:

1. A surface stratum from 2 m. to the surface.
2. An intermediate stratum from 5 m. to 2 m.
3. An " " " 10 " " 5 "
4. An " " " 25 " " 10 "
5. A deep " " 50 " " 25 "
6. A " " " 100 " " 50 "
7. A " " below 100 "

Twenty hauls each were made for the first two groups, while only two fall in the last group, and in all calculations, except the first table where all hauls are recorded, these are included in the stratum above as from the bottom to 50 m. The amount of plankton under one square meter of surface obtained in the various hauls from Lake Michigan is shown in the following table:

Number of Station	IX.	X.	XI.	XIII.	XV.	XVI.	XVII.	XVIII.	XIX.	XX.	XXI.	XXII.
2 m. to surface	19.37	18.46	22.08	28.42	25.34	27.15	23.35	26.25	25.70	18.46	23.17	17.74
5 m. to surface	40.73	26.25	35.30	41.63	31.13	42.35	44.35	33.67	34.93	31.68	35.11	24.98
10 m. to surface	54.66	47.78	66.61	79.64	53.40	80.91	88.69	49.23	58.83	49.59	50.32	49.41
25 m. to surface	117.29	96.84	115.48	169.24	------	126.34	159.28	90.14	118.56	82.90	88.69	75.84
50 m. to surface	116.02	106.79	157.83	148.17	------	------	179.19	89.60	? ? ?	110.05	------	101.36
Bottom to surface	------	------	170.32	------	------	------	160.37	--------	------	------	------	--------
Depth of bottom haul	26	53	112	30	10	23.5	130	36	36	41	22	42

The amount for the deepest stratum in each column represents the haul from the bottom, this usually does not coincide exactly with the deep limit of the stratum, but its extent can easily be told by the depth of the station, which is given in the lowest line of figures.

Corresponding figures for the stations in Round and Pine lakes are given in the next table.

Number of Station	V.	VI.	VII.	XXIII.	XXV.	XXVI.
2 m. to surface	23.89	22.99	30.41	29.32	21.72	25.52
5 m. to surface	29.14	42.54	54.30	33.49	34.08	26.97
10 m. to surface	44.16	--------	56.65	45.43	56.11	47.06
15 m. to surface	59.01	60.64	68.60	--------	47.80	--------
Bottom to surface	63.35	68.42	94.12	69.32	--------	49.05
Depth of bottom haul	22	30	30	17 5	15	21.

If now the amount given for the surface stratum of any station be subtracted from the amount taken in the haul from 5 m. to the surface, the remainder may be held to represent the amount in the stratum from 5 m. to 2 m. In the same way we may obtain the amount for the stratum from 10 m. to 5 m. and for that from 25 m. to 10 m., as also for the strata from the bottom to 25 m. The results for the Lake Michigan hauls are given in the next table; they are, however, calculated to the nearest single decimal only.

Number of Station	IX.	X.	XI.	XIII.	XV.	XVI.	XVII.	XVIII.	XIX.	XX.	XXI.	XXII.
2 m. to surface	19.4	18.5	22.1	28.4	25.3	27.2	23.4	26.3	25.7	18.5	23.2	17.7
5 m. to 2 m.	21.4	7.8	13.2	13.2	5.8	15.2	21.0	7.4	9.2	13.2	11.9	7.2
10 m. to 2 m.	13.9	21.5	31.3	38.0	22.3	38.6	44.3	15.6	23.9	17.9	15.2	24.4
25 m. to 10 m.	62.6	49.1	48.9	89.6	------	45.4	70.6	40.9	59.7	33.3	38.4	26.4
50 m. to 25 m.	-1.3	10.0	42.4	-26.1	------	------	19.9	-0.5	???	27.2	------	25.5
Bottom to 50 m.	------	------	12.5	------	------	------	-18.3	------	------	------	------	------
Depth of bottom haul	26	53	112	30	10	23.5	130	36	36	41	22	42

These artificial strata are, however, of very different thickness and in order to compare the amounts contained in them with each other it is necessary to reduce them to a common term, namely, the amount of plankton per cubic meter of water. This is done by dividing the total amount in any stratum for any station by the thickness of the stratum, and the results are given in the next table.

Number of Station	IX.	X.	XI.	XIII.	XV.	XVI.	XVII.	XVIII.	XIX.	XX.	XXI.	XXII.	Average.	
													Volume	Per cent.
Amount per cu. m. in stratum 0-2 m.	9.7	9.2	11.0	14.2	12.7	13.6	11.7	13.1	12.9	9.2	11.6	8.9	11.5	*47.5*
In stratum 2-5 m.	7.1	2.6	4.4	4.4	1.9	5.1	7.0	2.5	3.1	4.4	4.0	2 4	4.1	*16.9*
" " 5-10 m.	2.8	4.3	6.3	7.6	4.5	7.7	8.9	3.1	4.8	3.6	3.0	4.9	5.1	*21.1*
" " 10-25 m.	4.2	3.3	3.3	6.0	------	3.4	4.7	2.7	4.0	2.2	3.2	1.8	3.5	*14.4*
" " 25-50 m.	-1.3	0.4	1.7	-5.2	------	------	0.8	-0.0	???	1.7	------	1.5	0	------
" " 50 m. to bottom	----	----	0.2	----	------	------	-0.2	------	------	------	------	------	0	------
Depth of bottom haul	26	53	112	30	10	23.5	130	36	36	41	22	42	----	------

It is at once apparent that the surface stratum contains a much greater amount, than any other stratum, on the average more than twice as much. The intermediate strata are not far from equal, and the deeper strata are almost without plankton. Reighard found in Lake St. Clair that the amount in the surface stratum which in his experiments was taken to be only of one and one-half meters in thickness, was greater than the total amount below, but this was evidently due to the shallowness of the water. In Lake Michigan it was nearly true of the shallowest station in the table (XV), but at all others the total amount below the two meter level was much greater than that above that line. Proportionally, however, the surface stratum is always much richer than any of those below it. In this connection it should be pointed out that the upper level, be it 1.5 or 2 m., is most susceptible to error. The time is estimated with great difficulty and hence the velocity is hardly correctly obtained. When an average velocity is made the basis for the correction of all hauls, as in the table used here, this difficulty is of little importance. More weighty errors are due to wave motion and to the difficulty of limiting exactly the depth desired since the error is a much greater part of the whole than the same amount would be for deeper stratal hauls. One would expect, however, errors in both directions, and since the *minimum* amount of plankton in the surface stratum is more than the *maximum* amount in any other deeper stratum it is evident that the difference in the true volumes of the strata is greater than double the possible error. Furthermore, the fluctuations in the amount of plankton contained in the surface stratum are not due to this alone since they are no greater than the variations for other strata where these errors play a lesser and evidently somewhat insignificant part.

The amounts in the various strata in Pine and Round lakes are obtained in like manner, by subtraction, and are as follows:

Number of station	V.	VI.	VII.	XXIII.	XXIV.	XXV.	XXVI.
2 m. to surface	23.9	23.0	30.4	29.3	29.0	21.7	25.5
5 m. to 2 m.	5.3	19.6	23.9	4.2	-1.5	12.3	1.5
10 m. to 5 m.	15.0	18.1	2.4	11.9	--------	22.1	20.1
15 m. to 10 m.	14.9		12.0	23.9	------	-8.5	2.0
Bottom to 15 m.	4.3	7.8	25.5		------	--------	
Depth in meters	22	30	30	17.5	4.	15	21

If, now, the amounts per cubic meter of water in each stratum be found as before, the table becomes:

Number of Station	V.	VI.	VII.	XXIII.	XXIV.	XXV.	XXVI.	Av. volume.	
								In cc.	Per cent.
Amount per cu. m. in stratum 0—2 m.	11.9	11.5	15.2	14.7	14.5	10.9	12.8	13.1	*64.8*
In stratum 2 to 5 m.	1.8	6.5	8.0	1.4	-0.7	4.1	0.5	3.1	*15.3*
" " 5 to 10 m.	3.0	1.8*	0.5	2.4	--------	4.4	4.0	2.7	*13.3*
" " 10 to 15 m.	3.0	1.8*	2.4	3.2	------	-1.7	0.2	1.3	*6.5*
" " 15 m. to bottom	0.6	0.5	1.7		------	------			
Depth of haul in meters	22	30	30	17.5	4	15	21	--------	--------

Here again it is evident that the surface stratum contains much more than any equal amount of water below it, in every case at least twice as much, and on the average four times as much as any other stratum. Both the average and the extremes show that the surface stratum in Round and Pine lakes contains noticeably more plankton than the surface stratum in Lake Michigan. The deeper strata, however, appear to be decidedly poorer than those in Lake Michigan.

The results given in these last two tables are much more easily examined when represented graphically, as in Plate II. As before, the vertical lines represent stations and the horizonial lines volumes or depths as indicated at the margin. The order of the various stations is the same as that of Plate I, and the dotted line of depth (D) is repeated here for convenience.

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* These were not taken as two separate hauls but together as one. See table page 32.

The points representing volumes of plankton per cubic meter of water at various depths are connected to form lines, *S* of the surface stratum, 2–5, 5–10, etc., of the other strata. The interrogation points on XIX indicate, in the case of the one at 8.8 cc. the total actually obtained for the stratum 25–50 m., sand and all included (see p. 45), and in the case of the upper mark, a possible true value for the plankton less sand and other extraneous matter. At VIII the mark indicates that the observation for this depth is lacking. The line *B* on Plate II^A represents the stratum 15 m. to bottom, which does not correspond exactly to any in Lake Michigan. Otherwise the strata are represented by similar lines on the two portions of the chart.

The results from Lake Michigan (II^A) may well be considered first separately from those of Round and Pine lakes (II^B). The line (*S*) of volumes in the surface stratum (0–2 m.) pursues a somewhat irregular course from one side of the chart to the other. The irregularities in it are independent of the depth and, as comparison with Plate I^A shows, also of the total volume and of the relative volume of plankton. I have plotted on charts not given in this report the fluctuations for these hauls in temperature of this stratum and in time of day without finding any general agreement between them and the variations in the amount of plankton in the surface stratum. These latter may be due in part at least to errors in the apparatus, in the methods of obtaining, or measuring the plankton, or they may depend upon the combined effect of several causes. At present, however, the irregularities must be left unexplained.

The lines representing the three intermediate strata occupy a mean position on the chart. They are subject to very considerable variations which bring first one and again another uppermost, but which are never sufficient to confuse any one of them with the lines of the surface stratum or of the deeper layers. On the plate the line of volumes per cubic meter of water in any stratum is marked by the limits of the stratum, *eg.* 2–5 m., but in the discussion each may well be designated by the numeral of the deeper limit of the stratum, thus the 5 m. line would indicate the line of plankton volumes per cubic meter of water in the stratum 2–5., or bottom if shallower than 5 m.

The 5 m. line shows no relation to the line of depth, nor to that of the surface stratum, and only an uncertain parallel to the line of total volumes (Plate I^A), as if it in general influenced the direction of the latter. The 10 m. line appears to have no fixed relation to the line of depth, to that of total volumes, or to the 5 m. line. There is, however, a striking agreement in direction with the line of the surface stratum; what may be the significance of this I am unable to say. At one station (IX) only is the 10 m. line on the chart, far above the 5 m. line, at two (XXI, XX) it is a little higher and at all others decidedly lower, thus indicating more positively than the average of the table (p. 50) that the 5–10 m. stratum contains more plankton per cubic meter of water than the 2–5 m. stratum. At IX the 2–5 m. stratum seems to have gained plankton at the expense of both the surface stratum and that of immediately below itself (5–10 m.) The possible significance of this will be discussed later.

The 25 m. lines shows no particular relation to the lines of depth, of total volumes, or of the surface stratum. It is more nearly parallel to the 5 m. line than to the 10 m. line, and on the chart lies below the latter in one case only (IX) while it is above the 5 m. line in seven cases and below in four. The amount of plankton per cubic meter of water is, then, in the 10–25 m. stratum clearly less than in the 5–10 m. layer and considering the number of cases more nearly equal to the amount per cubic meter of water in the 2–5 m. stratum than the average of the table (p. 50) would indicate. The amount of plankton in the intermediate strata is variably more or less, and relatively nearly the same for the various stata, but always much less than in the surface stratum and equally clearly more than in the deeper strata. It is less than zero in one instance only, for the 2–5 m. stratum at XII.,* where the depth of the haul is only 4.3 m.

The 50 m. line shows no apparent relation to any of the others; it indicates a negative amount of plankton in at least three cases IX, XIII, XVIII, and never more than a very small positive amount. The same is true in still greater degree of the 100 m., or bottom line, which lies once just above and once just below the zero line. The amount of plankton per cubic meter of water in the deeper strata is thus clearly shown to be exceedingly small.

In Round and Pine lakes (Plate II^B) the relations are substantially the same. The line of the surface stratum stands for a little larger amount and shows less extreme fluctuations. The intermediate strata contain much less plankton and are much more variable in quantity. The high average of the 2–5 m. stratum in the table (p. 51,) is seen from the chart to be due evidently to the enormous bend in the line at VI and VII; at all of the other stations the 10 m. line shows a greater amount of plankton than the 5 m. line. There are in the shallower water of these lakes no strata corresponding to the deep ones of Lake Michigan, and the 10–15 m. stratum corresponds only to the upper third of the corresponding (10–25 m.) stratum in the large lake. In comparing these results with those in Lake Michigan it should be remembered that the meagre depth 30 m., of the deepest station entitles us to consider only the right hand portion of the other chart (II^B) up to and including XIII. The number of stations in Lake Michigan of equal depth is about the same as the total number in Round and Pine lakes.

In Lake St. Clair Reighard made hauls from 1.5, 3.0, 4.5 metres and bottom; if the second and third be added to the strata become 1.5, 4.5 and bottom which corresponds nearly with our strata of 2 m., 5 m., and bottom in the shallowest hauls. Combined in this way the hauls from Lake St. Clair yielded the following results where the volume of plankton under 1 square meter of surface is given in cubic centimetres.

Number of Station	II.	III.	V.	VI.	VIII.	IX.	XV.	XVI.
In stratum 1.5 m. to 0	10.3	15.8	11.1	8.0	9.4	7.6	7.5	7.1
" " 4.5 m. or 5 m. to 1.5 m.	0	-2.3	2.5	4.8	3.3	3.0	6.4	2.5
" " bottom to 4.5 m.	--------	4.9	3.1	--------	--------	--------	-3.0	--------
Depth of bottom haul in meters	5	5.5	5.3	4.8	4.4	4.3	5.2	4.6

By dividing in each case by the number representing the thickness of the stratum, the amount per cubic meter in each stratum will be obtained. It is given in the next table:

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* By the use of the method of subtraction the amount of plankton in any stratum may become apparently less than zero where the total amount in the stratum is less than the fluctuations in the measured amount of the plankton in the superjacent water whether those fluctuations are due to errors in apparatus employed, in calculation or in measurement, to actual variations in the amount of plankton present, or finally to a combination of these causes. It will then evidently be most likely to occur where the depth of the bottom stratum is only small and where it is poorest in plankton. Instances of negative plankton quantities due to the limited thickness of the bottom stratum are probably XII, IX, XIII, to poverty of the bottom stratum XVIII, XVII, though both causes undoubtedly affect some of the cases to a certain degree.

Number of Station	II.	III.	V.	VI.	VIII.	IX.	XV.	XVI.	Av.
In stratum 1.5 m. to 0	6.9	10.5	7.4	5.3	6.3	5.1	5.0	4.7	6.4
" " 4.5 or 5 m. to 1.5	0	–0.8	0.8	1.5	1.1	1.1	2.1	0.8	0.8
" " bottom to 4.5 m.	--------	4.9	3.9	--------	--------	--------	–4.3	--------	1.5

Compared with the averages from Lake Michigan and Round and Pine lakes as given in the tables, pp. 50 and 51, it is at once evident that the surface stratum in Lake St. Clair, contains only about half as much plankton as that in the other lakes; there is still less in the second stratum. The bottom layer was present in so few cases that one can not draw any inferences from the exceedingly variable amounts given in the table above. They show, however, on the average about half as much as is found in the third stratum in Round and Pine lakes.

When these results are plotted (Plate III) it is seen that the amount per cubic meter in the surface stratum undergoes a gradual increase with increasing depth. This, which was not true of the waters of the Charlevoix region, may be a characteristic of the extremely shallow water. One can think that the true plankton forms do not reach the conditions for most favorable development until further removed from the influence of the bottom than the meagre 2 to 3 meters of the shallow hauls in Lake St. Clair. This supposition is apparently strengthened by the facts shown in the average of the table on the preceding page and is still more clearly evident on the plates.* The amount of plankton in the surface stratum is only about half as much in Lake St. Clair as in the northern waters, but in the deepest water of the former lake the amount is about the same as the smallest quantity recorded in the Charlevoix region. I am inclined to believe then that the amount of plankton in the surface stratum increases with the depth for very shallow waters until a certain maximum is approximated, and then is independent of the depth of the water. This is, however, hardly more than a working hypothesis at present and deserves further careful investigation.

The stratum 4.5–1.5 m. shows a certain decrease with increasing depth of water, the reverse of conditions in the surface stratum while the few observations on a deeper stratum, bottom to 4.5 m., agree in general tendency to increase with the surface stratum. The amount in the middle stratum is evidently far below that in the northern lakes and the variations are more intense since the amount of plankton present becomes nearly zero more than once. In this respect, the lines on Plate II^{B}, for Round and Pine lakes agree more nearly with Lake St. Clair than do those of Lake Michigan.

The peculiar tendency of proximate strata to show variations in opposite directions is evident in Lake St. Clair as well as in Lake Michigan, in connection with which the matter is discussed. Here it is only necessary to say I regard this peculiarity as evidence of vertical migration of part or all of this plankton under circumstances not yet known.

One feature deserves further discussion. No doubt it has already been noticed that the comparison between stratal hauls in the lakes is open to criticism since in Lake St. Clair the limits are not the same as in the northern lakes studied. It is true that as yet no definite information is at hand as to the exact position in a stratum which the mass of the plankton holds and if in Lake St. Clair a considerable part of the plankton from the stratum 1.5–4.5 m. were to have been found in *the upper half meter* of that stratum the total for the surface two meters would more nearly or quite equal that in the same limits in Lake Michigan. In the work on Lake St. Clain the stratal hauls employed were 1.5–0, 3.0–0, 4.5–0, and bottom –0. Now it is a curious fact, and perhaps not without bearing in the present discussion, that the method of subtraction gives for the four strata an average amount of plankton per cubic meter of water of 6.4, 1.6, –0.1, and 1.5 cc. That is of the two layers, each one and one-half meters thick, which constitute the stratum 4.5–1.5 m., most nearly corresponding to that of 5–2 m. used in the Charlevoix work, *the deeper one contains on the average a little less than nothing.* This shows distinctly that the bulk of the plankton in Lake St. Clair, between the limits of 4.5 and 1.5 meters is accumulated in the upper half of the stratum; how much more narrowly it is limited cannot be told. Hence it may still be true that the upper two meters contains an amount equal to the surface stratum in Lake Michigan. If this is so, however, it is all the more true that the deeper water contains a minimal amount of plankton, far below that which is found in the waters of the Charlevoix region.

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* Plates I, II, III, are all drawn on exactly the same scale.

One interesting general relation deserves special notice here though it has already been hinted at in the preceding. There seems to me to be evidence of opposite variation in adjacent strata and of parallel variation in strata once removed from each other, i. e., decrease in the surface stratum seems to be accompanied in a majority of instances by increase in the 2–5m. stratum and decrease in the 5–10m. stratum; and at least one of these two fluctuations appears to be generally characteristic of changes in any line. I am inclined to think this is evidence of vertical migration, under circumstances not yet apparent, of some elements of the plankton which, being normally near the artificial line of separation of two strata such as we used, would cause contrary variations in the two strata by passing from the one into the other. Reighard (93, p. 35) gives similar evidence of vertical migration by the contrary variation of proximate strata in Lake St. Clair. The solution of such questions depends, however, upon the location and movement of the species which constitute the plankton.

In the work of Apstein on the Lakes of Holstein, the artificial strata employed were 0 to 2 meters, 2 to 10 meters and 10 meters to bottom. To compare the results of this work on Lake Michigan with his the amounts for the various strata must be added so as to give layers corresponding here to those he employed. If the table on p. 50 be treated so as to combine the strata in this way, the following table is made, showing in cc. the volume of plankton under 1 sq. m. of surface for each stratum at each station:

Number of Station	IX.	X.	XI.	XIII.	XV.	XVI.	XVII.	XVIII.	XIX.	XX.	XXI.	XXII.
2 m.—surface	19.4	18.5	22.1	28.4	25.3	27.2	23.4	26.3	25.7	18.5	23.2	17.7
10 m.—2 m.	35.3	29.3	44.5	51.2	28.1	53.8	65.3	23.0	33.1	31.1	27.1	31.6
Bottom—10 m.	61.3	59.1	103.8	63.5	......	45.4	71.7	40.4	* 16.5	60.5	38.4	51.9

* Estimated.

Or reduced as before to common terms for comparison.

Number of Stations	IX.	X.	XI.	XIII.	XV.	XVI.	XVII.	XVIII.	XIX.	XX.	XXI.	XXII.	Av.
Amount of plankton per cu. m. of water in surface stratum	9.7	9.2	11.0	14.2	12.7	13.6	11.7	13.1	12.9	9.2	11.6	8.9	11.5
In 2—10 m. stratum	4.4	3.7	5.6	6.4	3.5	6.7	8.2	2.6	4.2	3.9	3.4	3.9	4.7
In 10 m.—bot'm stratum	4.4	1.4	1.0	3.2	......	3.4	0.6	1.6	* 1.5	2.0	3.2	1.6	2.2

If now the amount of plankton in the bottom stratum of each station in the above table be taken as a unit for that station and the upper strata expressed in terms of it, the results will show the relative distribution of plankton. This has been done in the next table.

Number of Station	IX.	X.	XI.	XIII.	XVI.	XVII.	XVIII.	XIX.	XX.	XXI.	XXII.
Surface stratum	2.2	6.6	11.0	4.4	4.0	19.5	8.2	8.6	4.6	3.6	5.6
2 to 10 m. stratum	1	2.6	5 6	2.0	2.0	13.7	1.6	2.8	2.0	1.1	2.4
10 m. to bottom	1	1	1	1	1	1	1	1	1	1	1

Apstein has made similar comparisons for one of the largest of German lakes, Dobersdorfersee near Kiel, and gives the following table of relations for that body of water, which has however only the limited depth of 20 m. at most.

Date	VII. 5	VII. 19	VIII. 2	VIII. 30	IX. 20	X. 4	X. 11	XI. 15	III. 27	IV. 13	V. 11
Number of haul	26	27	28	30	32	33	34	37	41	43	46
Stratum 0 to 2 m	1.7	2	4.2	8.9	7.9	1.7	2.9	4.2	6.8	2.5	3.8
" 2 to 10 m	1	1	0.9	8.9	2.9	0.2	0.6	1	2	0.5	0.9
" 10 to 20 m	1	1	1	1	1	1	1	1	1	1	1

The date of our work was August, so that comparisons should be made properly only with the first three hauls of this table; they are, however, all much alike, and show greater uniformity than those from Lake Michigan given in the preceding table. This is no doubt due to the difference in depth, for the two deep stations in Lake Michigan, XI with 112 m., and XVII with 130 m., are just the ones in which the surface stratum is extremely large in proportion to the deep stratum. The other stations, especially the shallower ones, IX, XIII, XVI, XXI, show a proportionate distribution of plankton approximately like that found by Apstein. This is the more unexpected and interesting when the amount of plankton in the two lakes is considered, for Dobersdorfer See is rich in plankton, whereas Lake Michigan belongs to those lakes denominated plankton poor. Hauls of equal depth show the latter very clearly.

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* Estimated.

	Lake Michigan.				Dobersdorfer See.			
Number of haul	XII.	XIV.	XV.	XXI.	25	27	26	27
Depth of haul in meters	4.3	8	10	22	5	7	18	19
Total amount of plankton in cc. under 1 sq. m. of surface	27 24	-------- 65	-------- 53	-------- 89	379 530	-------- 227	909 909	530 720

In hauls from equal depths there is about ten times as much plankton under 1 sq. m. of surface in Dobersdorfer See as is found in Lake Michigan. Yet not only is the amount in the surface stratum of both greater than the amount in any other equal portion of the water, but it is also true that the two lakes show a greater similarity in percentage of vertical distribution of the plankton. This may be formulated as follows:

*Partial vertical hauls from equal depths yield equal volumes in the same lake, and equal percentages in different lakes.**

If we consider the relations shown by the lines on Plate II^{A}, a more natural combination of the strata used in the work on Lake Michigan than that used by Apstein for those of Dobersdorfer See, would be, (1) the surface stratum alone, richest in plankton; (2) the three intermediate strata, nearly equal to one another in amount of plankton present in each; (3) the deep strata uniformly poor in plankton.

For comparison the results are brought together into another table which gives the amount of plankton in cubic centimeters under one square meter of surface for the three sets of strata:

Number of station	IX.	X.	XI.	XIII.	XVI.	XVII.	XVIII.	XIX.	XX.	XXI.	XXII.
2 m. to surface	19.4	18.5	22.1	28.4	27.2	23.4	26.3	25.7	18.5	23.2	17.7
25 m. to 2 m.	97.9	78.4	93.4	140.8	99.2	135.9	63.9	92.8	64.4	65.5	58.0
Bottom to 25 m.	-1.3	10.0	54.9	-26.1	------	1.1	-0.5	?	27.2	--------	25.5

By dividing the total amount in each stratum by the thickness of the stratum for each station, the table shows the amount of plankton in cubic centimeters per cubic meter of water at each station:

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* Since writing the above I have seen a paper by Walter (95). He speaks of quantitative plankton measurements as "an invaluable aid in the investigations" of the shallow breeding ponds on which he worked, and prefers measurements to weighing for their convenience and accuracy. The paper is almost exclusively devoted to methods, but one general principle of plankton distribution, cited without the data on which it is founded, deserves mention here. He says: "In a cubic meter of water taken from a shallow area the amount of plankton is greater than in a cubic meter from a deeper place," and further "I do not know to what extent this is true of deeper bodies of water." As will be seen, this is a somewhat general statement of the relations between the depth and the amount of plankton which are discussed more precisely in the preceding pages. Independent and concurrent observations on the value of plankton measurements and on the variation in amount with depth in bodies of water affording such sharply contrasted conditions as the shallow carp ponds and the Great Lakes are certainly powerful arguments for the accuracy of plankton studies and also in support of the general principles elucidated in this particular case.

The importance of depth as a factor in determining the amount of plankton is further evident from the observations of Zacharias (95). He states (p. 119) that there is an evident dependence of the amount of plankton on the depth of the water, but what may be the interrelation is not stated more exactly in that place. An examination of his records of hauls shows that it must be in general the same as that we found in Lake Michigan and elsewhere. It should be noted that only series of hauls made within a comparatively limited time can be compared for this purpose, since the well-known seasonal variations in the plankton certainly affect markedly the volumes of hauls made at considerable time intervals from each other.

Number of Station	IX.	X.	XI.	XIII.	XVI.	XVII.	XVIII.	XIX.	XX.	XXI.	XXII.	Av.
In stratum 0 to 2 m.	9.7	9.2	11.0	14.2	13.6	11.7	13.1	12.9	9.2	11.6	8.9	11.5
" " 2 to 25 m.	4.3	3.4	4.1	6.1	4.3	5.9	2.8	4.0	2.8	2.8	2.5	3.9
" " 25 m. to bottom	–1.3	0.4	0.6	–5.2	------	0	0.	?	1.7	------	1.5	?
Thickness in meters of deepest stratum	1	28	87	5	------	105	11	11	16	------	17	--------

If for each station of this table the amount of plankton in the intermediate stratum be taken as a unit, and the amounts in the surface and deep strata be expressed in terms of this unit, the result is as follows:

Number of Station	IX.	X.	XI.	XIII.	XVI.	XVII.	XVIII.	XIX.	XX.	XXI.	XXII.	Av.
Surface stratum	2.3	2.7	2.7	2.3	3.2	2.0	4.7	3.2	3.3	4.1	3.6	3.1
Intermediate stratum	1	1	1	1	1	1	1	1	1	1	1	1
Deep stratum	–0.3	0.1	0.1	–0.8	------	0	0	------	0.6	------	0.6	0.0

This table demonstrates once more and clearly that (1) the surface two meters contain much more plankton per cubic meter of water than any stratum below it, and (2) the deep stratum is practically devoid of plankton in comparison with the upper portions of the water.

This relative superiority of the surface stratum in plankton contents was first demonstrated in European lakes by Apstein. As already noted these lakes are of limited area and depth, and moderate inflow and outflow. Reighard found the same plankton distribution in Lake St. Clair which is greater in area, less in depth and extremely unstable in volume owing to the enormous inflow and outflow. The observations recorded here serve to show similar conditions in the Charlevoix region of Lake Michigan, which, even in the limited region examined, is much larger in area, many times greater in depth and extremely stable in volume owing to the small inflow and outflow. At the same time we found like conditions in Round and Pine lakes, one very small and changeable, the other large and comparatively stable. In the light of these observations on widely separate and extremely dissimilar bodies of fresh water, it may fairly be assumed to be a general truth that the surface stratum contains more plankton than any other equal portion of the water. In Lake Michigan, as also in Round and Pine lakes it was equally true that the amount of plankton in the surface stratum is independent of the depth.

The question naturally suggests itself as to the distribution of the plankton within this stratum. The surface towings in Round and Pine lakes and Lake Michigan were ordinarily made at about 8 a. m., and the blanks on which were recorded the daily catches show unmistakably that the plankton at the immediate surface contained algæ and rotifers, but only very rarely crustaceans and then but few of them. The amount of these tows was never taken carefully and measured but they showed themselves at a glance to be meagre in comparison with towings from deeper levels. In order to test the matter more carefully I had a net of peculiar pattern constructed. From its general appearance it received at the hands of the party the name of "torpedo" net. A cylinder of wire gauze was reenforced by bands of brass at both ends and by three longitudinal brass wires of one-eighth inch in diameter, soldered to the gauze and strengthened by external hooks of wire. The front end was provided with a tight fitting, solid funnel which had external eyelets so that it could be firmly fastened to the ends of the longitudinal rods on the outside of the cylinder. Three of these funnels were used, having openings of 0.5, 0.75, and one inch in diameter. The other end of the cylinder was also closed by a funnel but of gauze with an oil can top at the end. The inside of the cylinder and of the lower funnel was lined by a net of fine India linen. From the cord which towed the net a lead weight was suspended about a foot in front of the mouth of the front funnel. Thus equipped it could be drawn behind our fishing tug at full speed and yet remain well below the surface of the water. The amount of water which could enter was regulated by the opening of the funnel and was small enough to allow of its filtering through the large lateral area of the net so as to leave the plankton in good condition. The material washed back along the sides of the net and collected in the rear funnel from which it was taken when the net was hauled in. We dragged this net for several days during our trips on Lake Michigan and for hours at a time. Yet the amount of plankton obtained was exceedingly small. No reason can be given why the water should not have passed through the net in large quantities during these long trips and so far as we could see it did. There was no means at hand of measuring the amount filtered and of recording the permanency of the stream entering the funnel; this is of course the vulnerable point of the evidence. Apparently, however, the apparatus worked well and continuously, and unless some reason can be found why the plankton could not enter the net, we are forced to grant that at that time of day the amount of plankton in the upper foot of water is practically *nil.** These experiments were made during the day. Unfortunately there was no opportunity to repeat them after nightfall. Surface towings were, however, made in Round and Pine lakes from a row boat after dark. With the same net, in the same way and at the same place, where in daylight a scanty collection of rotifers and algæ was made, the darkness yielded a rich haul including multitudes of crustacea. It was only the upper six to twelve inches of the water which was filtered in both cases. This evidence, scanty and incomplete as it certainly is, still points, to my mind unmistakably, to the existence of diurnal migrations on the part of the crustaceans at least. This well known occurrence in salt water has been found by Francé (94) to take place in the case of fresh water forms in Lake Balaton, Hungary; Marsh (94) has also observed it in Green Lake, Wis. In a recent publication Birge (95) denies the existence in Lake Mendota, Wis., of such migrations at least beyond the limits of three meters. I have already called attention to the fact (p. 55), that vertical migrations, carrying large numbers of a species over the limits of the artificial strata used in the lake work, would cause the compensatory fluctuations in adjacent strata as shown on the plates. It is true that if the hauls made in the Charlevoix region are plotted with reference to the time of day there does not seem to be any correlation between the time of the hauls and the variations in amount. Of course it should be noted that the hauls we made were never very late in the day and the supposed vertical migrations may have been due to entirely different causes if, indeed, they actually occurred.

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* While very kindly reading the proof, Prof. Reighard called my attention to the fact that he reached a similar conclusion in a paper read before the American Fisheries Society (see Report for 1892). Neither the paper nor the volume are accessible to me at date of writing.

I have already called attention to the compensatory fluctuations in the plankton of adjacent strata from Lake St. Clair; these are very striking if one examines the results given by Reighard for the strata of only 1.5 m. in thickness and are *more than half of them eliminated by combining the two strata 1.5-3 m. and 3-4.5 m.* Mention has also been made above of the comparative barrenness of the lower half of the stratum 1.5–4.5 m.

All of the peculiarities noted in this connection point in one direction and justify the conclusion that *the distribution of the plankton within the limits of an artificial stratum is very unequal; the variations in its distribution are probably due to vertical migration.*

One further question in vertical distribution demands brief consideration. We have seen that the amount of plankton per cubic meter of water varies inversely as the depth from which the water is obtained. Does the volume decrease constantly from surface to the bottom or is there near the latter an increase, an accumulation of forms more or less dependent upon the bottom? No exact observations were made to determine this point, but some data bearing upon the question were recorded. In the qualtiative studies made during the first two weeks on Round and Pine lakes, and Lake Michigan it was customary to have a tow taken by an ordinary surface net and and also one taken by a runner net drawn along the bottom. This was let down open through the water and drawn up open also, so that its contents were in no sense strictly bottom forms, nor was there any means of using them in quantitative determinations. It was customary to draw both this bottom net and the surface net about an equal length of time. Now while we noticed from the first that the surface net, as already mentioned, obtained but a small amount of material, chiefly Rotifera and Protozoa, it was also remarked that the bottom net brought up a host of specimens, and that these were almost entirely Crustacea. The mass of material was composed, as examination showed, of only a few species, but these few were present in such enormous numbers of individuals as to make the catch a veritable "soup." In my daily note book this richness of the bottom tow was commented on for days until we recognized it as a constant occurrence and among the notes I find the statement that the tow appeared as rich in quantity as any evening surface tow on the ocean. I was in fact thoroughly astonished to find such masses in fresh water catches. There was practically an entire lack of the numerous insect larvæ which make the volume of some fresh water hauls so great; the tow consisted of almost nothing but myriads of Copepoda. Now these were either migrants from the superjacent water or permanent residents of a zone near the bottom. The vertical hauls gave no evidence of the existence of this mass of Crustacea near the bottom, although the hauls were made at the same place and at corresponding times of day. I wish to point out here some faults in this negative argument and to emphasize the fatal error in placing entire dependence upon hauls of a *vertical* net. In the first place the impervious canvass cone brings the actual opening of the net about 40 cm. above the bottom when the net is actually resting upon a flat surface; stones and other objects as well as inequalities in the surface may increase this distance considerably. Again, the net is lowered to the bottom, rests there a second and is then hauled steadily to the surface. The bucket hanging below makes some disturbance in the water before the cone reaches the bottom, and the strong swimming forms, such as *Limnocalanus*, and other Copepoda, would have abundant opportunity to escape from the dangerous ground above the cone, the place of greatest disturbance and hence the point from which the fugitives turn. Both of these reasons would naturally tend to lessen the number of bottom forms taken in vertical hauls. The runner net also gave evidence of a considerable number of *Mysis* near the bottom, but as might be expected they were taken only rarely and by twos or threes in the vertical net.

This is the vertical distribution characteristic of the warmer season of the year when, not only in respect to light but also in regard to temperature, the surface stratum is much the most favorable portion of the water for growth. In regard to only one of these factors do the conditions remain the same throughout the year, the light supply is uniformly greater at the surface in all seasons, but during the fall it is known that the temperature of the water becomes more and more uniform throughout and finally in the winter the deeper strata are actually warmer. I know of only one observation as to the effect of this change in temperature on the relative populousness of the various strata. Birge (95, p. 480), records that during the fall the distribution becomes more and more uniform throughout the water and that the surface stratum does not show any superiority in the amount of plankton present in it. If this be confirmed for other bodies of water it will be evidence that the factor of temperature has more effect on the distribution of the plankton than the light.

No opportunity has yet been found for qualitative work on the hauls of the vertical net. The counting of such a mass of material would involve more time than it has been possible for me to devote personally to that purpose and no other opportunity has yet offered itself. I am personally skeptical of the value of enumeration under ordinary circumstances and most of all of such efforts as are not extended throughout the year to afford a basis for estimating the rise and decline of various species.

It is evident of course that not all the plankton is equally valuable as fish food and not all of it seems directly or indirectly to form marketable fish. As has already been mentioned the Crustacea form the most important element from the standpoint of the fish culturist. While I with the assistance of one or more members of the party, was taking hauls with a vertical net at one side of the boat, Professors Birge and Marsh with some assistance were securing stratal hauls of Crustacea alone at the other side of the tug. Each of these gentlemen, who contributed so much to the results of the work in other directions also, brought with him a specially constructed closable net of his own designing so constructed that it could be lowered, closed, opened, raised a given distance, closed again and brought to the surface. One of the nets has already been described (Birge 95, p. 423) and the other will be shortly. At times both of the nets were used together and again a series of hauls was made with one only. The coarser cloth used in the net, the smaller amount of material obtained and the greater rapidity with which a pure crustacean haul filters, made it possible for them to secure a series of hauls from 2 and 5 meters and then every ten meters to the bottom even in the deepest places, in the same time that was consumed in making with the vertical net the series of hauls already described. These hauls are to be counted in the simplified method described by Birge (95), and will make an exceedingly valuable contribution to the vertical distribution of this most important element of fish food contained in the plankton.

SWARMS IN THE PLANKTON.

In the preceding pages an effort has been made to show uniformity of horizontal distribution of the plankton as a whole and the absence of such accumulations as might be termed "swarms." From the evidence obtained here and elsewhere I am led to believe that swarms of the entire plankton do not exist and furthermore I can see no variations of biological conditions which should accumulate *all* the life in the water within certain areas, large or small, and leave other areas more or less devoid of life. Even on the land where conditions are so much more variable that environment in the water is relatively stable, no such local accumulations are found. It is true that areas of considerable extent are more densely populated than other parts of the land, and the jungles of the tropics, for instance, are sometimes said to "swarm" with life. In the same way Agassiz (88) speaks of that portion of the continental slope and of the opposite island slope which is washed by the Gulf Stream as crowded with life. In these and similar instances there is a comparison of considerable areas with distant portions equally large. This is not in the least parallel with what some have believed to be plankton swarms. Investigators have declared that within the narrow limits of small bodies of water and frequently at points proximate to each other the total amount of plankton varies so greatly as to warrant the assumption of contiguous populous and barren areas in the water, that is the existence of swarms of the entire plankton. Now the work of Reighard in Lake St. Clair and Apstein and Zacharias in Holstein lakes and the results of this work on Lake Michigan have shown clearly, in my opinion, that this is not the case. In the preceding pages is given evidence that the total amount of plankton does vary, but that it varies in accord with the depth and that beyond this there are no variations considerable enough to warrant the assumption of the existence of swarms of the plankton as a whole. It would not be strange if the exact amount of plankton varied, perhaps considerably, at the two ends of Lake Michigan and certainly some shallow plant-filled lakes in the vicinity of Charlevoix and in free communication with the main lake by small yet perfectly open channels do contain a much larger amount of plankton than Lake Michigan itself, yet the first possible variation is as little evidence of swarms as the latter.

How do the separate species conduct themselves in this respect? Are they also nearly equally distributed, or is there reason to think that they may occur in swarms? The inequality in seasonal distribution of various species is well known. Thanks to the work of Zacharias a considerable number of species have been watched from day to day and it seems clear that most forms pass through one or more cycles of variation in each year. Such a cycle includes a period of advance, of increase in numbers, a maximum, a time of decline and decrease in numbers, and finally a minimum, or often a period of total disappearance from the plankton. These cycles are coincident with seasons or changes in temperature. Birge (95) has recorded similar variations for species in Lake Mendota. Such variations as these are characteristic of entire bodies of water, or at least very large areas in a body of water. The species appears everywhere almost at once and its disappearance is similarly general. It is not evidence of swarms to record, as Zacharias does (95, p. 120 *ff.*), that a certain species was abundant in one place and wanting on the other side of a long island which almost completely divided the lake into a northern and a southern half. It must first be shown that the conditions which determine the development of the species, temperature, food, etc., are alike in both places, and no evidence on these weighty questions was sought or furnished. But even then it is as little evidence on species swarms as the fact that a certain fish may be caught in plenty here and is lacking there is proof of that that particular fish goes in schools!

The word "swarm" seems to need a more precise definition in the light of conditions known and easily observed. To my mind it is some such massing of individuals as is seen in a school of fish, a flock of birds, a herd of wild cattle. The idea is certainly not precise in quantity since any one of these aggregations may consist of only a few individuals or of many hundreds. They are, however, definite bands collected for breeding or feeding purposes, or for protection, or having been produced by excessive multiplication, they still remained in a localized mass. If this be a correct interpretation of conditions, then neither those accumulations of plankton or single species made at certain points by the chance of wind or current, nor yet these normal variations in the number of any species within a given area due to the more favorable environment, can be properly spoken of as *swarms*.

Recurring to conditions on the land we see that swarms of the entire plankton are not to be expected and in fact the possibility of such may well be doubted. In making only quantitative determinations of the plankton species swarms, if existing, are apt to escape notice or even to be masked by the normal variations in the total amount, by errors in method, apparatus, or manipulation and by the alternation of swarms of different species. Furthermore it is certain that if such swarms do exist there is a constant tendency to destroy them in the action of winds, waves and currents.

A species swarm will affect the total volume of plankton very little, i. e., not noticeably in contrast with other variations, if the species is ordinarily very common, if it is of small size or if it is one of many species (*polytonic* plankton). On the other hand the total volume of the plankton will be considerably affected if the species swarming is of large size, commonly rare, or if the plankton is *monotonic* (composed of but few species). Of course all grades between these two extremes are possible and a considerable factor will be the size of the swarm i. e., the number of individuals of which it is composed.

The evidence heretofore collected as to the existence of species swarms seems to me insufficient. So for instance the enumeration of a certain species taken in a haul from a depth of 40 m. shows at one time 400 individuals, at a second haul 1,100, a considerable increase to be sure, but not such evidence as to establish the occurrence of swarms. If it be true that the species is equally distributed over the entire depth, and the contrary is not even suggested in the context, then every cubic meter held at the time of the first haul 10 individuals, at the second 28. One section of land holds now 10 cattle, later 28; where is the evidence of herds? It is evident that actual proof of the occurrence of swarms demands more exact and detailed evidence than has yet been furnished. We collected no positive evidence upon this point, but one circumstance tends to my mind to establish the probability of the occurrence of swarms under some circumstances. During one of our trips on Lake Michigan the runner net was drawn over a certain area of ground off Fisherman's Island several times. Each haul brought up a good catch of crustacea, but in one there was such a mass of *Limnocalamus* that they formed a solid mass of several ccm. The number was fifty or one hundred times greater than that obtained in the other hauls. That this was the result of including some local aggregation of the species, i. e., some swarm, is the most evident, if not the only explanation of the case. On another day Mr. Jennings reported a mass of *Asplanchna* at the surface just off the lighthouse pier so great that thousands could be taken at every haul of a net thrown from the pier. A few hours later not one was there. This may have been, however, a wind collection or even a current collection. Of course the surface is peculiarly liable to such aggregations by the effect of wind or current and the deeper water more independent of such influences.

PINE LAKE.

The town of Charlevoix is built on a narrow neck of land which separates Lake Michigan from Pine Lake (see map). The circular basin of Round Lake, which affords a fine harbor for the shipping and fishing industries of the place, lies nearly half way between the lakes first named, and is in free and open communication with both by channels of considerable size. The laboratory was located on the shore of Round Lake near the building in use by the Michigan Fish Commission as a hatchery, and the situation naturally caused us, in making the preliminary studies, to turn our attention first to Round Lake and then to Pine Lake and Lake Michigan. In the course of these studies some features of interest were manifested by the comparison of the three bodies of water, and these were supplemented by some special observations on the part of the botanist of the party, Mr. Thompson. From their importance in connection with the general question of fish culture, certain of the biological characteristics deserve brief consideration here.

Round Lake, a scant half mile in diameter, is little more than an enlargement in the course of the stream by which Pine Lake empties into Lake Michigan The connection between these lakes has been modified for commercial use by dredging, so that now a five meter channel, protected externally by piers and a lighthouse (see map), connects Round Lake with Lake Michigan. Between Pine Lake and Round Lake the old stream, which has been entirely replaced by a straight dredged connection, lies at one side, a shallow tortuous brook, known as the "Old Channel." The broad, deep and straight artificial channel renders communication between the lakes very free and a current runs indifferently in either direction, depending upon the direction of the wind, and no doubt also on the level of Lake Michigan and Pine Lake. This results, of course, in more or less of a mixture of the forms of life, especially of those plankton species which occur in the two.

Round Lake is simply intermediate ground, and in the character of its plankton resembles now the one, now the other of the larger lakes so that it possesses no characteristic features in distinction from them. With the docks which line a large part of its shore and the continuous disturbance and pollution of its waters, there is little opportunity for the development of aquatic plant life; yet those portions of the lake which offer any possible foothold are fairly well supplied with water plants, noticeably the shallow banks and the quiet waters of the old channel.

Pine Lake is a body of water in which, as in Lake Michigan, conditions are very stable. The area which drains into it is evidently limited, as a glance at the map will show, and the size of the lake itself is such that the inflow and outflow form but a small percentage of the total volume. There is a current running into the lake at the outlet quite as frequently and quite as powerfully as there is in the opposite direction. The shore is, in large part, sand and gravel for a short distance from the margin, but nearly the whole bottom of the lake is composed of marl, in which one finds a host of shells in good preservation. From washings of the marl, Mr. Walker identified the following forms:

- *Limnæa desidiosa* Say.
    - *catascopium* Say.
    - sp.
- *Physa integra* Hald. (young).
- *Planorbis bicarinatus* Say.
    - *parvus* Say.
- *Valvata tricarinata* Say.
    - *sincera* Say.
- *Amnicola porata* Say.
    - *lustrica* Pils.
- *Goniobasis livescens* Mke.
- *Sphærium striatinum* Lam.
    - *simile* Say.
- *Pisidium abditum* Hald.
    - sp.
- *Unio luteolus* Lam. (dead).
    - sp. (dead).
- *Anodonta* (young) (dead).
    - *Footiana* (?) Lea.

He adds concerning these shells: "A very few of the *Amnicola* and *Valvata* were alive. Everything else was dead and most of it had the chalky appearance of fossil specimens from the marl."

On the marl one finds no living thing save here and there scanty tufts of dwarfed *Chara*, which was never found in fruit; it was uniformly encrusted by a heavy calcareous coating.

The absence of plants along the shore in the shallow water and on the sandy or gravelly bottom is also noteworthy. Isolated patches do occur but they are thrifty and abundant only in a few places, the most prominent of which are on the south arm of the lake. It will be noticed that the axis of the main lake lies directly in the path of the northwest winds and it has occurred to me that this may be the cause of the absence of shore vegetation, since the wash along the shore of a lake as large and deep as this would be too powerful to allow the growth of plants even where the bottom was of a suitable character. In the smaller and more protected south arm there is a much larger amount of vegetation. We were unable to make any exact observations in that part of the lake.

Pine Lake has undoubtedly undergone some considerable modifications within recent geological times. The old outlet to the northward is easily traced through a line of tamarack swamp to Susan Lake; thence to Lake Michigan it follows a small stream which is at present the outlet of Susan Lake. The marl bottom which underlies a very considerable part of Pine Lake can by borings be found not far below the surface at various points around the lake. The gravel and glacial drift are evidently at present being washed out into the lake over the marl and the thickness of the layer decreases gradually as one recedes from the shore. Mollusca are not very abundant and while the species recorded by Mr. Walker are recent and most of them at least found in this locality at present, the existing conditions are inadequate to account for such a bed of marl and I am inclined to believe it the bed of an older lake now gradually disappearing.

The importance of these considerations is evident when we come to examine the fauna and flora of the lake.

I have already mentioned the striking lack of vegetation, both littoral and bottom. Mr. Thompson, who spent some time in a careful examination of the shore says in this connection, "The entire absence of *Myriophyllum*, *Utricularia* and the aquatic species of *Ranunculus* is perhaps significant. The scarcity of plants is apparently due to the marl bottom as all the fairly thrifty plants which do occur are found growing on bottom more or less modified by deposits of sand or alluvial sediment." Similar mention of the limited amount of life discovered in Pine Lake may be found in the reports on the Protozoa (p. 81), Rotifera (p. 88), and Mollusca (p. 98), published in appendices to this paper. Of the insect fauna Dr. Wolcott writes:

"This poverty of the Pine Lake fauna was in marked contrast to the richness of that of the neighboring small inland lakes, in which was to be seen both in respect to number and identity of species and abundance of individuals, a marked similarity to that of Lake St. Clair, indicating the effect of the like conditions, while at the same time it emphasized the contrast between both and Pine Lake."

The plankton studies on Pine Lake discussed on a previous page and plotted on Charts I^B and II^B, show that the surface stratum contains if anything somewhat more plankton than the same portion of Lake Michigan but the deeper strata very much less, so that in shallow water (VIII) the total amount of plankton is approximately the same as in Lake Michigan while in the deeper water (XXVI to VII) the total amount is far below that in the main lake.

After this resumé of other groups it will not be strange that fish are scarce in the waters of Pine lake. Neither those of Lake Michigan nor the species which inhabit the surrounding inland lakes would find any considerable supply of nourishment and in fact a few game fish, in the south arm chiefly, and a few whitefish in the eastern end of the main lake, are all that are reported for this body of water. The absence of a bottom flora and fauna, the scarcity of plankton and the paucity of littoral vegetation with the accompanying forms of life, particularly insect larvæ, are the factors which limit the introduction of various kinds of fish.

I have discussed the conditions here in full since it seems to me a powerful argument for the necessity of employing the experimental method. Such a magnificent lake with miles of shore and acres of beautiful clear water affords possibilities for existence to a multitude of fish. The reasons for their non-existence are apparently clear, and if so the problem is half solved. In some way more vegetation must be made to grow in the lake, perhaps different species of plants introduced. If forms can be found which are capable of growth and increase on a marl bottom, the fish producing power of the lake will be multiplied enormously and in the place of a scanty population the waters will support large numbers of valuable food fish. I have endeavored to ascertain the species of water plants which thrive upon marl bottomed lakes elsewhere, but the question proved to be beyond the facilities at my command. This offers under favorable circumstances a rich field for experimentation.

CONCLUSIONS.

In addition to the more special conclusions stated in connection with various topics there are some general conclusions, especially with reference to the plankton and its bearing on fish culture, which are summarized as follows:

I. The plankton is the source of food supply for all lake fish; its rapid reproduction affords a constant supply in spite of continued destruction.

II. The amount of plankton in Lake Michigan in the region examined is limited. The enormous area compensates for this limited amount.

III. The plankton is uniformly distributed horizontally. At this season of the year it is accumulated near the surface, and very little is contained in water below a depth of 25 meters, except that a second accumulation near the bottom is probably usual. At this season, then, no fish will be found regularly or in numbers in the nearly barren intermediate water below 25 m., except it be in the water near the bottom.

IV. The uniform horizontal distribution of the plankton indicates that the plankton-eating fish find food in limited quantities everywhere.

V. The bottom flora and fauna are not extensive enough to support large numbers of bottom feeding fish within circumscribed areas. The well known migrations of whitefish schools along shore seem thus to be correlated with the non-localized food supply.

VI. There is a plentiful supply of whitefish food on the old fishing grounds. No reason can be assigned for the diminution in the supply of whitefish save overcatching.

In conclusion I should like to emphasize one point which seems to grow clearer as the work proceeds; if the experience of two years has shown anything, it has demonstrated that the possibilities in this line of investigation can hardly be limited, but that future developments which are so essential to the fisherman and the fish culturist alike, are distinctly dependent upon the facilities for carrying on the investigation under permanent conditions.

It may be hoped that something has been accomplished during the two years of this work inaugurated under the auspices of the Michigan Fish Commission and carried on by voluntary and hearty cooperation on the part of various scientific workers. Yet it is evident that progress along this line will be necessarily slow and that at times, as in the present instance, other peremptory duties will encroach upon the time of the workers and delay the publication of the reports. Furthermore, no one can appreciate so well as one who has tried it, how enormous is the mass of work connected with an enterprise inaugurated in a new field of work, and compelled to originate at once methods and appliances with repeated delay and even failure.

It is equally true that the possibilities of future development will be clearest to those who have taken a part in the enterprise. Yet others can not fail to apprehend its importance and the necessity of continuing it. To my mind it is clear that in order to attain its proper results the work must be put on a definite basis. It must be rendered permanent and placed in the immediate charge of workers who shall devote to it their entire time. If any measure of success has accompanied it in the past while it has been under the direction of those whose time was necessarily limited or when perhaps it has been carried out as a side issue in connection with the regular work of some fish hatching station, it is none the less true that it demands and deserves the full attention of able and trained investigators.

There should also be mentioned in this connection the mass of experimental work which must be done. It is of vital importance for the solution of problems which present themselves in connection with the biology of the lakes and their inhabitants, that experimental investigation should be possible in order to test the results, to answer questions, and to suggest possibilities that would otherwise remain undeveloped. No one can have read the preceding pages without having appreciated continually the questions suggested in connection with the most varied topics; no one can fail to see that the results attained should be supplemented or controlled by experiment.

The life of the young white fish, its food and growth while in the state of nature, the best age and place for planting, and hundreds of other questions which suggest themselves in connection with this particular topic cannot be decided in a few weeks work of a summer party however well equipped and located, Questions with reference to the yearly variations in the plankton and those problems suggested in connection with the discussion of these questions early in the report, cannot be solved until a permanent biological station shall be able to observe and to experiment continuously throughout the year. Already efforts have been made on a limited scale at least, towards the increase and multiplication of the food supply of fresh water fish and in some small ponds of Europe it has met with moderate success. The discussion of Pine Lake suggests an equally fertile field of study. The possibilities of the future are evidently dependent upon the possibilities for investigation and experiment. Aquaculture must be given the same sort of scientific treatment that agriculture already receives at the hands of the thousand trained investigators in experiment stations that are located in every state of the Union. It must be studied from the same scientific standpoint; its problems analyzed, its course marked out definitely; not until then can it render that service to the people which the opportunity of our inland seas makes possible in the way of a food supply at once cheap and agreeable. Let me quote from an address before the American Microscopical Society: "Fish culture will never attain its proper results until it receives by the liberality of the State and nation the same favors that have been extended to agriculture, the use of permanent and well equipped experimental stations where trained workers shall devote all their time and energy to the solution of its problems. The Great Lakes furnish a cheap and valuable food supply to one-third of our entire population, This food supply is rapidly becoming depleted. How long must such important interests wait their just recognition and adequate protection? And if properly developed, who can limit the possibilities of these Inland Seas in supplying the nation with food?" The urgent need of the present is not a mere biological observatory, however valuable such a permanent foundation might be, but a well-equipped and well-directed experiment station to attack the peculiar problems of fish culture in the Great Lakes.

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NOTE—Since the earlier pages of this report were in print there has appeared "The Lakes of North America" by I. C. Russell; Ginn & Co., Boston, 1895. This gives (p. 57 to 63) physical data on the Great Lakes more fully and accurately than any authority previously at my command. The figures quoted on pages 8 and 9 of this report should be slightly modified, but the argument and conclusions are in no way affected. Much additional information of interest on the physical features of the lakes may also be found in the work cited.

APPENDIX I.

REPORT ON THE PLANTS.

BY H. D. THOMPSON, MOLINE, ILL.

For the three weeks beginning August 2, 1894, it was the good fortune of the writer to be with the investigating party maintained at Charlevoix by the Michigan State Fish Commission. During this time there was made some study of the minute plant life of Lake Michigan and a botanical survey of Pine Lake was begun. The time did not suffice for the proper handling of either task.

Pine Lake is a marl bottomed basin of a type not rare in northwestern Michigan. Unlike many of the small lakes which line the shore of Lake Michigan, its greatest length, instead of lying parallel with the adjacent shore line of the larger lake, forms with it a large angle. Some fifteen miles long and in its broadest portion three miles wide, and very irregular in outline its shore line exceeds ninety miles. Its western end is rather more than a mile from Lake Michigan with which it communicates freely through Round Lake. The natural water ways from Pine Lake to Round Lake and from the latter to Lake Michigan have been so improved for purposes of navigation by large lake boats, as to render communication much freer now than formerly.

The shore of the lake rises in two bold terraces which appear with much regularity and clearness at Belvedere, and though sometimes broken, in places effaced by erosion, and often lying at considerable distance from the present shore line, they may still be traced along the lake for long distances to the eastward, and are continuous around Round Lake on both sides and thence along Lake Michigan both to the northward and southward.

At present the lake consists of a long, narrow, central basin twenty to twenty-five meters in depth with a uniform regular marl bottom, extending from Charlevoix at its western end to Boyne at the eastern, surrounded by shallower waters including all coves and bays and a marginal area of varying width along the shore.

The bays are all rather shallow, the bottom sloping away gradually from the shore line toward the edge of the basin, which in each case extends across the mouth of the bay in a line between points in front of the headland on either side.

In general the bottom drops off evenly until, at a distance of two hundred twenty-five to three hundred twenty-five meters from shore there is a depth of about fifteen meters; then in course of two or three rapid casts of the lead eighteen to twenty-one meters is found, and the lead comes up bearing soft sticky marl. Exceptions were noted in which the gentle slope was continuous from the shore line, for a full half mile into the lake, before the twenty meter depth was reached. One and one-half miles N. E. of Advance a depth of twelve meters was found at fifty meters from shore; twenty meters, fifteen meters farther out, and within another twenty-five meters the lead dropped down twenty-six meters, to the end of our sounding line, but found no bottom.

The beach of Pine lake varies from sand in certain localities to calcareous gravel or even soft marl in others. The bottom of the shallow marginal portion naturally partakes of the character of the adjacent beach, but invariably shades off to a marl as deeper water is reached. In some bays surrounded by cedar swamps the bottom is of soft, blackish mud, part marl, part alluvial deposit. In a few places where a bold sandy terrace approaches the shore line closely, the bottom is of clean sand for a long distance out toward deep water.

The flora of Pine Lake is exceedingly meager. The observer may row along its shore for miles without seeing one thrifty bed of water weeds, and may dredge back and forth over a hundred acres of bottom without securing a handful of vegetation. In water varying from three to seven meters in depth were found scanty beds of *Chara* sp., never of thrifty well grown plants, never in fruit and always encrusted with calcareous material. Along shore, in water one and one-half to three meters in depth, occur a half dozen thin and rather small beds of *Potamogeton perfoliatus* L. Half way up the lake on the north side, on sand bottom, was a fairly thrifty and good sized bed of *Scirpus pungens*, *Potamogeton perfoliatus* L., *Potamogeton lucidulum*, *Naias flexilis* and *Chara* sp. In the edge of this bed toward deep water several fishing stakes were noticed.

Some bass fishing being reported in Oyster bay on the south side of the lake, it was examined with some care. Oyster bay is an arm of the lake a half mile wide and nearly one and a half miles long. At the mouth the bottom slopes gently away from the shore on either side to a depth of nine meters near the middle. It becomes shallower steadily as its head is approached, ending in a marsh which shades off to the surrounding cedar swamp. Separated from this bay by a stretch of cedar swamp lies Susan Lake. In Oyster bay the bottom is of marl and black sediment mixture previously mentioned and vegetation is more plentiful than we found it elsewhere in the lake. A mile or more of shore line about the head of the bay is fringed with thrifty beds of *Scirpus pungens* Vahl., and *Scirpus lacustris* L.; *Potamogeton perfoliatus* L. occurs in several places. *Acorus calamus* L. and *Typha latifolia* L. also occur here though not noted elsewhere in the lake. The bottom bears numerous and fairly thick beds of *Chara* sp., the same as found elsewhere in the lake. There was everywhere a striking scarcity of algæ and the entire absence of *Myriophyllum*, *Utricularia* and aquatic species of *Ranunculus* is noteworthy.

The examination of material collected by tow net and dredge from the neighboring waters of Lake Michigan, Round Lake and Pine Lake for minute life, which had been in progress for several weeks, was near completion at the time the writer became a member of the Fish Commission party. Material was examined, however, and data collected, sufficient perhaps to indicate certain obvious facts, though not sufficient foundation for any complicated or detailed conclusions.

As might be expected from the free communication between Lake Michigan and the smaller lakes, the three lakes vary little in flora. The open, wind agitated waters, unobstructed by the larger aquatic plants, and for the most part of considerable depth, afford but poor harbor for the filamentous algæ, Desmidiæ and Characeæ so abundant in the waters of Lake St. Clair investigated by the commission in 1893. The tow net and dredge, therefore, collect but little of such material, but the Diatomaceæ are ever present.

Of the algæ *Pandorina morum* Bory., is most frequently met, occurring chiefly in surface tows, sometimes in great abundance. The stray specimens noted in deep tows may have been taken by accident, as the net was lifted from the water. Bottom tows and dredgings in Lake Michigan show fine colonies of *Nostoc commune. Vaucheria tuberosa* also is common clinging to rocks, waterlogged bits of wood, etc., often at considerable depth It occurred in great abundance on fishing grounds off High Island, with *Chara* sp., the dredge teeth soon becoming entangled with bushels of this mixed material. In Pine Lake the surface net not infrequently collected bits of *Spirogyra* sp., *Zygnema* sp., *Oscillaria elegans* Ag., *Lyngbya* sp. The fragments were always quite small, generally so far gone to pieces as to be of doubtful identity and were probably from beach pools washed into the lake by receding waves during high wind.

The Desmidiæ were not represented in any material examined from Lake Michigan, Round Lake or Pine Lake. In a surface tow from Twin Lakes, the following were noted:

Cosmarium brebissonii Menegh.
C. marginatum Menegh.
C. reniforme.
C. subcrenatum Hantzsch.
C. undulatum.
Pediastrum ehrenbergii Corda. (H. Br.).
Sphærozasma filiforme Rab.
Staurastrum corunulatum Wolle.
S. grallatorium Nord.

The Diatomaceæ, greatly outnumbering all other plants both as to species and individuals, force themselves constantly upon the attention of the botanist. Individuals are generally present in much greater numbers in deep than in surface tows, but the distribution of species appears to be influenced but little by depth of water. The stipate forms are of course more often found in the neighborhood of a congenial support, but with little regard to the depth of this support below the water surface. The following species were noted, most of them in great numbers:

Asterionella formosa Hass., common in both surface and deep tows.

Cocconema lanceolatum Ehr., frequent in dredgings.

Coscinodiscus radiatus Ehr., occasional among weeds.

Cyclotella rotula Kütz., in dredgings, infrequent.

Cymbella gastroides Kütz., common in deep and surface tows.

Cystopleura gibba (Ehr.) Kütz., common in surface and deep tows everywhere.

Navicula viridis (Nitzsch.) Kütz., common on weeds in shallow water.

Nitzschia dubia Wm. Sm., single specimen, among weeds near surface.
Nitzschia sigmoidea (Nitzsch.) Wm. Sm., in surface and deep tows.
Epithemia turgida Wm. Sm.
Fragilaria capucina Desm., deep and surface tows, very common.
Gomphonema geminatum (Lyng.) Ag., surface and (more often) deep tows.
Orthosira sp., like *O. Dikii* Wm. Sm., once in surface, once in deep tow.
Stauroneis phœnicenteron Ehr., deep tow.
Synedra affinis Kütz., surface and deep tows.
S. lunaris Ehr., among weeds in shallow water.
S. ulva (Nitzsch.) Ehr., in dredgings.
Tabellaria fenestra (Lyng.) Kütz., common everywhere.
T. flocculosa (Roth.) Kütz., common.

Washings from aquatic plants are, as is well known, generally rich in Diatomaceæ. The following species identified by D. B. Ward, M. D., of Poughkeepsie, N. Y. are from a small vial of material washed from *Chara* sp., previously mentioned as being dredged from the bottom in High Island harbor, Lake Michigan.

Achnanthidium flexellum.
Amphora ovalis.
Campylodiscus novicus.
Cocconeis placentula.
Cocconema cistula.
C. gastroides.
C. lanceolatum.
C. cymbiforme.
Cyclotella compta.
Cymbella ehrenbergii.
Encyonema limula.
E. prostratum.
E. turgidum.
Epithemia argus.
E. gibba.
E. turgida.
Eunotia arcus.
E. diodon.
E. pectinalis.
Fragilaria Harrisonii.
F. capucina.
Gomphonema capitatum.
G. constrictum.
G. coronatum.
G. intricatum, var. *pumilla.*
Melosira granulata.
Navicula affinis.
N. bacillum.
N. limosa.
N. oblonga.
N. nobilis.
N. radiosa.
N. perigrina.
N. trinodis.
N. viridis.
Nitzschia frustulum.
N. palea.
Odontidium hyemale.
Pleurosigma attenuatum.
Surirella bifrons.
S. biseriata.
S. elegans.
Stauroneis gracilis.
S. phœnicenteron.
Stephanodiscus astrea.
Synedraulna, var. *longissima.*
Tabellaria fenestrata.
T. flocculosa.

The writer desires to acknowledge his obligation and express his thanks to D. B. Ward, M. D., of Poughkeepsie, N. Y., for the identification of the above list of diatoms and to Mr. C. F. Wheeler, of Michigan Agricultural College, who has identified a considerable number of flowering plants.

APPENDIX II.

A REPORT UPON THE PROTOZOA OBSERVED IN LAKE MICHIGAN AND THE INLAND LAKES IN THE NEIGHBORHOOD OF CHARLEVOIX, DURING THE SUMMER OF 1894.

BY C. A. KOFOID, SUPERINTENDENT OF THE BIOLOGICAL STATION OF THE UNIVERSITY OF ILLINOIS, URBANA, ILL.

The observations in the following paper were made in the laboratory of the Michigan Fish Commission at Charlevoix from July 24 to September 1, 1894. The material examined consisted in the main of collections made at the surface and bottom, with fine muslin nets, principally in Pine and Round lakes and Lake Michigan. In addition to these, shore collections were made along Round, Pine, Susan, Twenty-six, East and West Twin lakes, either by dragging the Birge net through the weeds along the shore, or by gathering the vegetation—algæ, *Chara*, *Naias*, *Utricularia*, *Potamogeton*, *Myriophyllum*, and *Nuphar*—and keeping it in aquaria in the laboratory, or collecting "washings" from it for immediate examination. To the systematic examination of these shore collections but little time could be given as the plankton was the main object of our investigation.

The present paper makes no pretension to completeness. It is merely a list, a compilation from the daily record of the occurrence and distribution and relative abundance of such species as were identified during the six weeks of my stay at the laboratory. Many of the smaller Flagellata and Ciliata were not identified and no attention was paid to the Gregarinidæ and little to the ecto and endo-parasitic Protozoa of the denizens of the lakes examined. The present report does not include the collections made with the plankton net in Lake Michigan, nor those made by Dr. R. H. Ward with the Birge net in the lakes to the north of Charlevoix as these collections have not yet come into my hands. A continuous and more thorough investigation would undoubtedly greatly extend the list of Protozoa here reported for the locality. A few forms were found which could not be referred to any described species in the literature at hand.

The appended list records 81 forms, 76 species and five varieties. The list reported by Smith (Bulletin Michigan Fish Commission No. 4, 1894), for Lake St. Clair includes 32 forms, eighteen of which are to be found among those observed at Charlevoix.

The forms included in the present list are distributed as follows among the different groups:

Rhizopoda	22
Heliozoa	5
Mastigophora	20
Infusoria	34

RHIZOPODA.

1. *Amœba proteus* Leidy. Swampy shores of Pine Lake, and West Twin Lake. Not common.

2. *Amœba radiosa* Ehrbg. Swampy shores of Pine Lake. Rare.

3. *Amœba verrucosa* Ehrbg. Among the algæ along the shores of Pine Lake. Not common.

4. *Cochliopodium bilimbosum* Auerbach. A single specimen from washings from *Chara* obtained at High Island harbor was observed. The collections came from a depth of about 6 m. on whitefish grounds.

5. *Arcella vulgaris* Ehrbg. Twenty-six Lake, East and West Twin lakes, in shore collections. Occasionally found in the surface and bottom tow in Round Lake. Common in *Sphagnum*.

6. *Hyalosphenia elegans* Leidy. Common in *Sphagnum* along the shores of Pine Lake. Single specimen taken in surface tow at West Twin Lake.

7. *Hyalosphenia papilio* Leidy. Common in *Sphagnum* along shores of Pine Lake.

8. *Quadrula symmetrica* F. E. Schultze. Common in *Sphagnum* along shores of Pine Lake.

9. *Difflugia collaris* Ehrbg. Common among *Fontinalis* from shores of East Twin Lake.

10. *Difflugia constricta* Ehrbg. In shore collections from Twenty-six Lake. Rare.

11. *Difflugia globulosa* Duj. Occasional in shore collections at East and West Twin Lake and Twenty-six Lake; in *Sphagnum* along Pine Lake. Common in surface and bottom tows and hauls of the plankton net in Round and Pine lakes and especially in Lake Michigan. It is much more abundant in surface than in bottom tows and in Lake Michigan than in the smaller lakes. It is very resistant, remaining active long after other animals in the tow have perished because of foul water. The limnetic form cannot be distinguished specifically from the form found in shore collections and in *Sphagnum*.

12. *Difflugia lobostoma* Leidy. Taken in surface tow in West Twin Lake in shallow water; also in bottom tow in Round Lake in 16 m. of water. Rare.

13. *Difflugia pyriformis* Perty. Occasional in shore collections along Pine and Twenty-six Lake; also in bottom tow in Round Lake in 16 m. of water and in bottom tow in Lake Michigan, 2¾ miles from shore in a haul of the plankton net in 57 m. of water.

14. *Nebela barbata* Leidy. Occasional in Sphagnum along Pine Lake. Forms intermediate between *N. barbata* Leidy and *N. collaris* Ehrbg. were also found in the same locality. (See Leidy's Fresh Water Rhizopods of N. A., Pl. 24, Figs. 18, 19.)

15. *Centropyxis aculeata* Stein. In shore collections along Pine Lake, East Twin, Twenty-six, and Susan lakes. Also in bottom tows in Lake

Michigan, 1½ miles off New York Point in 24 m., and 2 miles off Norwood in 16 m. of water. Occasional.

16. *Centropyxis ecornis* Leidy. A single dead shell was found in shore collections from East Twin Lake. This is probably a variety of the preceding.

17. *Euglypha alveolata* Duj. Occasional in shore collections along Pine and West Twin lakes, in *Sphagnum* and washings from *Utricularia.*

18. *Euglypha ciliata* Ehrbg. A single specimen was taken in surface tow off Fisherman's Island, in Lake Michigan. Common in *Sphagnum* about Pine Lake.

19. *Euglypha cristata* Leidy. Rare in *Sphagnum* along shores of Pine Lake.

20. *Trinema enchelys* Ehrbg. Common in *Sphagnum* along the shores of Pine Lake. Occurred also in shore collections from West Twin Lake. A single specimen was noted in a haul of the plankton net in 55 m. of water, 2½ miles off Norwood in Lake Michigan.

21. *Cyphoderia ampulla* Ehrbg. In shore collections from Pine and West Twin lakes. Common, especially in *Sphagnum.* Occasionally found in bottom tows in Round Lake and once in Lake Michigan 2¾ miles from shore in a haul of the plankton net in 57 m. of water.

22. *Gromia mutabilis* Bailey. Common on floating colonies of *Ophrydium versatile* in East Twin Lake.

HELIOZOA.

23. *Vampyrella laterita* Fres. Rare, in shore collections from East Twin Lake and Twenty-six Lake, among algæ or on masses of *Ophrydium versatile.*

24. *Actinophrys sol* Ehrbg. Lake Michigan, Pine Lake, Round Lake, West Twin Lake. More abundant in surface than in bottom tows. Found also in shore collections. Common.

25. *Actinosphœrium Eichhornii* Ehrbg. Bottom tow in Round Lake, also in bottom tow in Lake Michigan, N. W. of Norwood, two miles from shore in 15 m. of water. Rare.

26. *Heterophrys myriapoda* Archer. Rare among algæ in pools along Pine Lake.

27. *Rhaphidiophrys viridis* Archer. In shore collections from East and West Twin and Susan lakes. Rare.

MASTIGOPHORA.

28. *Dinobryon sertularia* Ehrbg. The type as figured and described by Bütschli and Kent, is much less common than the varieties. It occurs however in surface and bottom tows in Round Lake and Pine Lake and in Lake Michigan, and in shore collections at West Twin Lake.

29. *Dinobryon sertularia* Ehrbg. var. *angulatum* Seligo. Most common of all varieties, occurring in surface and bottom tows in West Twin, Round, and Pine lakes and Lake Michigan.

30. *Dinobryon sertularia* Ehrbg. var. *divergens* Imhof. Very common in surface and bottom tows in Round and Pine lakes, and in Lake Michigan.

31. *Dinobryon sertularia* Ehrbg. var. *undulatum* Seligo. Common in Round and Pine lakes and in Lake Michigan in surface and bottom tows.

32. *Dinobryon stipitatum* Stein. Common in surface and bottom tows in Round and Pine lakes, most abundant in Lake Michigan. Intermediate forms connect this with the preceding species, and it should perhaps be reduced to a variety.

33 *Uroglena volvox* Ehrbg. Common in surface and bottom tows in Round and Pine lakes and in Lake Michigan.

34. *Euglena viridis* Ehrbg. Common in shore collections along Pine, East Twin and Twenty-six lakes. Also found occasionally in bottom tow in Pine Lake at a depth of 15 m.

35. *Entosiphon sulcatum* Stein. Among algæ in pools along the shore of Pine Lake; common.

36. *Synura uvella* Ehrbg. Occasional in surface and bottom tows in Round and Pine lakes and in Lake Michigan.

37. *Mallomonas acaroides* Zach. In surface tow in shallow water in West Twin Lake; also in bottom tow in Pine Lake in 13 m. of water; occurring in both cases with the following variety; rare.

38. *Mallomonas acaroides* Zach., var. *producta* Zach. Common in bottom tows from Pine Lake, Aug. 4, but not found again during the summer except in small numbers in surface tow at West Twin Lake on Aug 6. Cysts were forming Aug. 4, and no individuals intermediate between the type and the variety were noticed in the material examined.

39. *Gonium pectorale* Ehrbg. Occasional in bottom tow in Pine Lake.

40. *Pandorina morum* Ehrbg. Occasional in surface tows in Lake Michigan.

41. *Volvox globator* Ehrbg. Rare in bottom tow in Round Lake.

42. *Diplosiga frequentissima* Zach. Common in surface and bottom tows in Round and Pine lakes and Lake Michigan on *Asterionella.*

43. *Chilomonas paramœcium* Ehrbg. Very abundant in shore collections which had stood in laboratory for several days. *Paramœcium aurelia* had been abundant in the same jars on previous day but decreased rapidly in numbers as *Chilomonas* multiplied.

44. *Peridinium tabulatum* Ehrbg. Frequent in surface tows in Lake Michigan, also in surface tow in West Twin Lake, and surface and bottom tows in Round Lake. Taken in small numbers with the Birge net in Susan Lake.

45. *Ceratium cornutum* Ehrbg. Frequent in washings from *Utricularia* from West Twin Lake; associated with a long slender form of *C. hirundinella* O. F. Müll. with divergent horns.

46. *Ceratium hirundinella* O. F. Müll. In shore collections from Pine, Round, Susan, East and West Twin lakes, occasional. Abundant in every surface and bottom tow in Round and Pine lakes, and especially in Lake Michigan. Triangular cysts were common in bottom tows and dredge washings during the first two weeks of August. They were also found occasionally in surface tows. A wide range of variation is exhibited by this species. The horns vary in number from three to six, also in the degree of their prolongation and divergence. Individuals with deformed, curved and even hooked horns were found. One three horned specimen had the left posterior horn bifid for about half its length.

47. *Glenodinium cinctum* Ehrbg. Common in shore collections along West Twin Lake especially in washings from *Utricularia.* Also found in surface and bottom tows in Lake Michigan, and in the latter part of August the gelatinous "cysts" containing one to three individuals were

common in surface and bottom tows in Round and Pine lakes and in Lake Michigan.

INFUSORIA.

48. *Coleps hirtus* Ehrbg. In shore collections from East and West Twin lakes. Frequent especially in aquaria that had stood for some days.

49. *Trachelius ovum* Ehrbg. A single specimen observed from pool along Pine Lake.

50. *Dileptus anser* O. F. Müll. In shore collections (Birge net) in West Twin and Susan lakes. Occasional.

51. *Nassula ornata* Ehrbg. Common on colonies of *Nostoc* and Diatoms and on Phryganeid egg masses brought up in the trawl off Beaver Island in Lake Michigan from a depth of 60 m.

52. *Frontonia acuminata* Ehrbg. Rare in shore collections at East Twin Lake, associated with *Ophrydium versatile.*

53. *Uronema marina* Duj. Very common in algæ in pools along Pine Lake.

54. *Paramœcium aurelia* O. F. Müll. Very abundant in shore collections from Pine Lake that stood in the laboratory several days.

55. *Paramœcium bursaria* Ehrbg. In washings from West Twin Lake; rare. Also taken with the Birge net in Susan Lake.

56 *Urocentrum turbo* O. F. Müll. Abundant in shore collections from West Twin Lake that had been standing in the laboratory for several weeks.

57. *Cyclidium glaucoma* Ehrbg. Among algæ in pools along the shore of Pine Lake; common.

58. *Conchophthirus anodontæ* Ehrbg. On *Anodonta, Unio* and *Limnea stagnalis.*

59. *Spirostomum ambiguum* Ehrbg. Among algæ in pools along Pine Lake, occasional.

60. *Stentor igneus* Ehrbg. Abundant in Round Lake upon *Chara.*

61. *Stentor igneus* Ehrbg. var. *fuliginosus* Forbes. Very abundant blackening the margins of the pools along the shore of Pine Lake, also in Round Lake upon *Chara.* Varies greatly in size and amount of black pigment.

62. *Stentor Rœselii* Ehrbg. Rare in shore collections in East and West Twin, Susan and Round lakes.

63. *Halteria grandinella* O. F. Müll. Common among algæ in pools along Pine Lake.

64. *Strombidium turbo* C. & L. Common in shore collections from West Twin Lake that had been standing in the laboratory for several weeks.

65. *Tintinidium fluviatile* Stein. A single specimen in bottom tow from Round Lake, made in 16 m. of water.

66. *Codonella cratera* Leidy. Surface and bottom tows, Pine Lake, and especially in Lake Michigan. Frequent. This species shows a wide range of variation in size, in the relative size of the aperture and the length of the neck. The number of rings on the neck varies from one to five, though in many cases no ring at all can be detected. Many individuals show no traces of the overarching ring about the aperture of the shell.

67. *Stichotricha cornuta* C. & L. Single specimen noted in shore collections from East Twin Lake.

68. *Oxytricha æruginosa* Wrz. Among algæ in pools along Pine Lake; occasional.

69. *Stylonychia mytilus* Ehrbg. Common in shore collections from East Twin Lake.

70. *Euplotes Charon* Ehrbg. Occasional among algæ in pools along Pine Lake.

71. *Aspidisca costata* Duj. Among algæ along shores of Pine Lake. Common.

72. *Trichodina pediculus* Ehrbg. On *Hydra*. This species has been reported by Zacharias (See Zeitschrift für Fischerei und deren Hilfswissenschaften, 1894, Heft 4) as parasitic on young whitefish, as many as 25 individuals being found on 4 sq. mm. of epidermis.

73. *Vorticella rhabdostyloides* D. S. Kellicott. Abundant on floating masses of *Anabæna* in surface and bottom tows in Round and Pine lakes and Lake Michigan.

74. *Vorticella campanula* Ehrbg. In shore collections from East and West Twin lakes; rare.

75. *Vorticella nebulifera* Ehrbg. Occasional in shore collections from Twenty-six Lake.

76. *Ophrydium versatile* O. F. Müll. In East Twin and Susan lakes. Common. Colonies reaching in some cases 125 mm. in longest diameter.

77. *Cothurnia crystallina* Ehrbg. On *Spirogyra* in East Twin Lake, occasional. A single small detached form taken in the plankton net within 3 m. of the surface is probably to be referred to this species.

78. *Lagenophrys ampulla* Stein. On the branchial appendages of *Hyalella dentata* Smith, from West Twin Lake; common.

79. *Stylohedra lenticula* D. S. Kellicott. Common on the caudal setæ of *Hyalella dentata* Smith, from Twenty-six Lake and bottom tows in Lake Michigan.

80. *Dendrocometes paradoxus* Stein. One detached dead specimen was found in the shore collections from West Twin Lake.

81. *Podophrya cyclopum* C. & L. On carapace of *Epischura lacustris* Forbes.

The nature of the lakes examined by the Fish Commission party in 1894 differs strikingly from that of Lake St. Clair examined in 1893. Lake St. Clair is a shallow lake with strong currents and an abundant supply of vegetation. Lake Michigan on the other hand has deeper water, feebler currents and little or no vegetation along its shores or on its bottom. Thus of Magnin's plant zones, the *Phragmitetum*, *Scirpetum*, *Potamogetonetum* and *Characetum* the last only is represented and that too in very limited areas, at least in the parts of the lake examined in 1894. This fact necessarily profoundly influences the character of the Protozoan fauna of the littoral zone and to a slight degree at least the qualitative character of the plankton itself, as it must reduce the number of occasional migrants from the littoral zone.

The conditions in Pine Lake resemble those of Lake Michigan in the absence of littoral vegetation and the limited area of the *Characetum*. Its fine marl and sand bottom affords no support to the alluvium loving water plants. Round Lake also is devoid of any considerable amount of vegetation; only a few scattered *Potamogetons* and isolated patches of *Chara* being found.

The Protozoan fauna of these lakes falls into two divisions representing (1) limnetic fauna—found free swimming or floating in the plankton and including relatively a very small number of species—and (2) littoral fauna.

LIMNETIC FORMS, (21.)

Difflugia globulosa.
Actinophrys sol.
Actinosphærium Eichhornii.
Dinobryon sertularia.
Dinobryon sertularia var. *divergens.*
Dinobryon sertularia var. *angulatum.*
Dinobryon sertularia var. *undulatum.*
Dinobryon stipitatum.
Uroglena volvox.
Synura uvella.
Mallomonas acaroides.
Mallomonas acaroides var. *producta.*
Gonium pectorale.
Pandorina morum.
Diplosiga frequentissima.
Peridinium tabulatum.
Ceratium hirundinella.
Glenodinium cinctum.
Codonella cratera.
Vorticella rhabdostyloides.
Podophrya cyclopum.

Of the 21 species included in the above list all belong to the active limnetic groups except the following which must be classed as passive limnetic forms:

Diplosiga frequentissima (on *Asterionella*).
Vorticella rhabdostyloides (on *Anabæna*).
Podophrya cyclopum (on *Epischura lacustris*).

There is not the least doubt that *Difflugia globulosa* is a prominent and during the period of observation, July 24–Sept. 1, constant member of the limnetic fauna. Its classification as an active form is perhaps questionable. With the exception of this Rhizopod, *Difflugia*, the Heliozoans *Actinophrys* and *Actinosphærium*, and the aberrant ciliate *Codonella*, all of the active limnetic species belong to the Mastigophora, are independent of a substratum for attachment and have holozoic nutrition. They share with the few pelagic algæ and diatoms the important function of furnishing food for the limnetic Crustacea which in turn are probably eaten by fish. They are thus an indispensable factor in the economy of the organic life of the Lakes.

In addition to the species in the above list which form the greater part of the Protozoan plankton there are many species of the littoral zone which are from time to time found in the plankton.

The following forms which probably belong to the littoral fauna have been observed in the plankton and further investigation would doubtless extend the list to include most if not all of the species of the littoral fauna.

Arcella vulgaris
Hyalosphenia elegans
Difflugia lobostoma
Centropyxis aculeata
Euglypha ciliata
Trinema enchelys
Cyphoderia ampulla
Euglena viridis
Volvox globator
Cothurnia crystallina

Actinosphærium Eichhornii and *Podophrya cyclopum* are also found in the littoral zone and might be included in the list as frequent migrants. *Actinophrys sol* on the other hand must be regarded as a limnetic as well as a littoral species inasmuch as mere migration is insufficent to explain its frequent and repeated occurrence in the waters of Lake Michigan miles from shore.

There is not sufficient evidence at hand for a distinction between the autolimnetic or surface, and the bathylimnetic or abyssal species inasmuch as the nets used for taking the bottom tow were not self closing and so called "bottom tow" included not only the bottom species but also those captured during the ascent of the net. The examination of the hauls with the plankton net will doubtless shed some light on the subject of the distribution of the protozoa in the bottom, the intermediate and the surface zones. So far as the evidence at hand goes, the indications are that the large majority of the limnetic species are found at both surface and bottom. *Difflugia globulosa* and *Actinophrys sol* are apparently more abundant in the surface tow. *Actinosphærium Eichhornii*, *Euglena viridis*, *Mallomonas acaroides* var. *producta*, *Volvox globator*, have been found mainly or only in bottom tows though all but one of these may be migrants, and all occur infrequently.

LITTORAL FORMS.

Lake Michigan has properly speaking no littoral zone. The sandy beach and the action of the waves prevent its formation and the migrants are probably carried down by the tributaries. In the case of Pine Lake however we can distinguish a slightly developed littoral zone with two distinct regions. (1) Shore pools; shallow bodies of water of small extent fed by springs. They contain a few dwarfed rushes, sedges and *Utricularias* and generally an abundance of algæ. In these pools the following species were found:

Amœba radiosa.
Amœba verrucosa.
Arcella vulgaris.
Actinophrys sol.
Vampyrella laterita.
Heterophrys myriapoda.
Entosiphon sulcatum.
Coleps hirtus.
Trachelius ovum.
Uronema marina.
Paramœcium aurelia.
Cyclidium glaucoma.
Spirostomum ambiguum.
Stentor igneus.
Stentor igneus var. *fuliginosus.*
Stentor Roeselii.
Halteria grandinella.
Oxytricha æruginosa.
Stylonychia mytilus.
Euplotes Charon.
Aspidisca costata.

(2.) Sphagnum: This is abundant in the cedar swamps (on the borders of Pine Lake) which are drained by brooks directly into the lake. In some places the *Sphagnum* comes to the water edge. Its Protozoan fauna consists mainly of Rhizopods. The following species were noted. Others doubtless occur.

Amœba proteus.
Amœba radiosa.
Arcella vulgaris.
Hyalosphenia elegans.
Hyalosphenia papilio.
Quadrula symmetrica.
Difflugia collaris.
Difflugia pyriformis.
Centropyxis aculeata.
Nebela barbata.
Euglypha alveolata.
Euglypha ciliata.
Euglypha cristata.
Trinema enchelys.
Cyphoderia ampulla.

The other inland lakes investigated had well developed littoral zones, abounding in plant life. The determination of the fauna of these lakes was confined to the examination of shore collections and this owing to the short time available for the purpose was necessarily very incomplete. Nevertheless it was here that the greatest number of species was found. The following were identified:

Amœba proteus.
Arcella vulgaris.
Hyalosphenia elegans.
Difflugia collaris.
Difflugia constricta.
Difflugia globulosa.
Difflugia lobostoma.
Difflugia pyriformis.
Centropyxis aculeata.
Centropyxis ecornis.
Trinema alveolata.
Cyphoderia ampulla.
Gromia mutabilis.
Actinophrys sol.
Vampyrella laterita.
Raphidiophrys viridis.
Dinobryon sertularia.
Dinobryon sertularia var. angulatum.
Synura uvella.
Mallomonas acaroides.
Mallomonas acaroides var. producta.
Chilomonas paramœcium.
Peridinium tabulatum.
Ceratium cornutum.
Ceratium hirundinella.
Glenodinium cinctum.
Coleps hirtus.
Dileptus anser.
Frontonia acuminata.
Paramœcium aurelia.
Paramœcium bursaria.
Urocentrum turbo.
Stentor Roeselii.
Strombidium turbo.
Stylonychia mytilus.
Stichotricha cornuta.
Trichodina pediculus.
Vorticella campanula.
Vorticella nebulifera.
Ophrydium versatile.
Cothurnia crystallina.
Lagenophrys ampulla.
Stylohedra lenticula.
Dendrocometes paradoxus.

The close similarity of the European and the North American Protozoan fauna is strikingly illustrated in the list of Protozoa observed at Charlevoix. Of the 81 forms identified at least 73 (and probably more) are also found in Europe.

Zacharias in the Forschungsberichte aus der Biologischen Station zu Plön, Theil II, lists 93 Protozoa as occurring in the Plöner See, 43 of which are contained in the present incomplete Charlevoix list. With two exceptions, *Podophrya cyclopum* and *Glenodinium cinctum*, every one of the limnetic species reported for our waters is also found at Plön. The limnetic Protozoa of the two continents are practically identical.

APPENDIX III.

REPORT ON THE ROTATORIA.

WITH DESCRIPTION OF A NEW SPECIES.

BY H. S. JENNINGS.

The Rotatoria are much less abundant in Lake Michigan and the waters connected with it, in the region of Charlevoix, than in Lake St. Clair. The limnetic species are fairly well represented, but littoral and bottom forms are rare on account of the character of the shores and bottom. These are almost everywhere of sand or clay and nearly without vegetation. The number of species found in these lakes is therefore scarcely more than half the number found in Lake St. Clair in the summer of 1893.

In some of the smaller lakes at some distance from Lake Michigan and not openly communicating with it, Rotifera are more abundant, the fauna here showing much more the characteristics of that of Lake St. Clair. The rotifers from these lakes will be reported separately, as will also a short list from the sphagnum swamps of the region.

The account therefore takes the following form:

1. List of Rotatoria from Lake Michigan and the two lakes in open communication with it (Round Lake and Pine Lake), with notes on distribution.
2. List of Rotatoria from pools on the sandy shore of Pine Lake.
3. List of Rotatoria from West Twin Lake.
4. List of some Rotatoria in material brought from Susan Lake.
5. List of Rotatoria from sphagnum swamps near Pine Lake.
6. List of species new to the fauna of Michigan.
7. Systematic and faunistic notes on certain species in the preceding lists, with description and figures of *Distyla signifera* n. sp.

1. LIST OF ROTATORIA FROM LAKE MICHIGAN, ROUND LAKE, AND PINE LAKE.

This list includes limnetic, littoral and bottom species from these three lakes and from the channels connecting them. The three lakes are included in one list on account of their open communication with each other and their similar characteristics; differences will be discussed in the notes at the end. The list does not include forms found in the shallow pools on the shores of Pine Lake, unconnected or only slightly connected with the main waters. These show a different character and are given in a separate list.

In order to show any differences in the fauna of the three lakes included in this one list, a letter is added in parenthesis, indicating in which lake or lakes the form was found. *M.* signifies Lake Michigan; *R.* signifies Round Lake; *P.* Pine Lake, and *C.* the natural channel connecting Round and Pine lakes. (See Pl. IV.)

The figures in parenthesis after the names of certain species refer to the systematic and faunistic notes at the end of the paper.

Rotatoria from Lake Michigan, Round Lake, Pine Lake, and the Channel Connecting Round Lake and Pine Lake.

Floscularia mutabilis Bolton. (M. R. P.)
Floscularia pelagica Rousselet. (M. R. P.)
Conochilus unicornis Rousselet. (M. R.)
Philodina roseola Ehrbg. (C.)
Philodina megalotrocha Ehrbg. (P. C.)
Philodina macrostyla Ehrbg. (M.)
Rotifer vulgaris Schrank. (P. C.)
Rotifer elongatus Weber. (M.)
Callidina musculosa Milne. (M.)
Asplanchna priodonta Gosse. (M. R. P. C.)
Asplanchna Herrickii de Guerne. (M. R. P.)
Asplanchnopus myrmeleo Ehrbg. (P.)
Ascomorpha ecaudis Perty. (M. R. P.)
Anapus ovalis Bergendal. (M. R. P.)
Synchæta stylata Wierz. (M. R. P.)
Polyarthra platyptera Ehrbg. (M. R. P.)
Notops pygmæus Calman. (M. R. P.)
Plœsoma lynceus Ehrbg. (M. R. P.)
Plœsoma Hudsoni Imhof. (M. R.)
Taphrocampa annulosa Gosse. (C.)
Notommata lacinulata Ehrbg. (R. C.)
Notommata monopus Jennings. (M. R. P.)
Copeus labiatus Gosse. (P.)
Proales laurentinus Jennings. (C.) (Note 2.)
Furcularia forificula Ehrbg. (P. C.)
Furcularia longiseta Ehrbg. (P. C.)
Triophthalmus dorsualis Ehrbg. (R. P.)
Eosphora aurita Ehrbg. (R.)
Diglena grandis Ehrbg, (C.)
Diglena forcipata Ehrbg. (C.)
Diglena catellina Ehrbg. (R. C.)
Mastigocerca carinata Ehrbg. (M. P.)
Mastigocerca bicornis Ehrbg. (M. R. P.)
Rattulus sulcatus Jennings. (C.)
Cœlopus porcellus Gosse. (C.)
Cœlopus tenuior Gosse. (C.)
Dinocharis pocillum Ehrbg. (R.)
Dinocharis tetractis Ehrbg. (M. C.)
Polychætus subquadratus Perty. (C.)
Polychætus Collinsii Gosse. (C.)
Scaridium longicaudatum Ehrbg. (P. C.)
Diaschiza semiaperta Gosse. (R. P. C.)
Euchlanis lyra Hudson. (R.)
Euchlanis deflexa Gosse. (C.)
Euchlanis oropha Gosse. (R. P. C.)
Cathypna luna Ehrbg. (C.)
Monostyla bulla Gosse. (C.)
Monostyla lunaris Ehrbg. (R. C.) (Note 6.)
Monostyla closterocerca Schmarda? (M. R. C.)
Metopidia lepadella Ehrbg. (C.)
Metopidia acuminata Ehrbg. (R.)
Metopidia Ehrenbergii Perty. (C.)
Brachionus Bakeri Ehrbg. (C.)
Anuræa aculeata Ehrbg. (M.)
Anuræa cochlearis Gosse. (M. R. P.)
Nothocla scapha Gosse. (M. R.)
Notholca foliacea Ehrbg. (R.)
Notholca longispina Kellicott. (M. R. P.)

Thus in these three connected lakes but fifty-eight species were found, as against one hundred and ten in Lake St. Clair during the preceding summer, though the investigation here was fully as thorough as that of Lake St. Clair. Twenty-four species were found in Lake Michigan, twenty-eight in Round Lake, twenty-five in Pine Lake, and twenty-nine in the shallow channel between Round Lake and Pine Lake. Lake Michigan has four species not found in the others, Round Lake five, Pine Lake two and the channel sixteen.

The great reduction in number comes especially in the littoral and bottom forms. The shores and bottom of Round Lake and Pine Lake were carefully examined, but the number of littoral or bottom forms is only twenty-three. The small number is due to the general absence of vegetation. The few *Chara* beds of Pine Lake harbor very few rotifers. The channel connecting Round Lake and Pine Lake is shallow and contains considerable vegetation, so that a comparatively large number—twenty-nine—of distinctively littoral rotifers were found here.

In Lake Michigan almost no littoral or bottom forms were found. In a few cases vegetation from deep parts of the bottom was brought up by the dredges; in this eight bottom forms were found. These are *Philodina macrostyla* Ehrbg., *Rotifer elongatus* Weber, *Callidina musculosa* Milne, and *Dinocharis tetractius* Ehrbg., dredged from a depth of sixteen meters, and *Ascomorpha ecaudis* Perty, *Mastigocerca carinata* Ehrbg., *Mastigocerca bicornis* Erhbg., and *Monostyla closterocerca* Schmarda, depth not recorded.

The limnetic forms of the list are as follows:

Floscularia mutabilis Bolton.
Floscularia pelagica Rousselet.
Conochilus unicornis Rousselet.
Asplanchna priodonta Gosse.
Asplanchna Herrickii de Guerne.
Anapus ovalis Bergendal.
Synchæta stylata Wierz.
Polyarthra platyptera Ehrbg.
Plœsoma lynceus Ehrbg.
Plœsoma Hudsoni Imhof.
Notops pygmæus Calman.
Notommata monopus Jennings.
Anuræa cochlearis Gosse.
Notholca longispina Kellicott.

Mastigocerca bicornis Ehrbg. was taken several times in the towings, and as has been noted by other observers, seems to be a transitional form between limnetic and littoral Rotatoria. Isolated specimens of some few other rotifers—*Euchlanis oropha* Gosse, *Ascomorpha ecaudis* Perty, *Monostyla closterocerca* Schmarda, *Monostyla lunaris* Ehrbg., and *Notholca scapha* Gosse—were taken occasionally in the towings, but these were evidently wanderers from the bottom or shore.

The list then contains but fourteen limnetic Rotatoria, as against twenty-four from Lake St. Clair. With farther observation I am inclined to believe that a number of those in the Lake St. Clair list are due to the shallowness and rank vegetation of that lake. As such, and as therefore not entitled to be called genuine limnetic forms, I should consider *Apsilus lentiformis* Metsch., *Ascomorpha hyalina* Kellicott, and *Mastigocerca capucina* Wierz. and Zach.

As to the relative abundance of the different species, there is a general, though not exact, agreement with Lake St. Clair. Exact records of the presence of the forms in forty-nine towings taken at different times or places showed the relative frequency of the more common species as follows: *Anurœa cochlearis* Gosse occurred forty two times; *Notholca longispina* Kellicott, forty-one times; *Notops pygmœus* Calman, thirty-eight times. These three commonest species were followed at some distance by *Synchœta stylata* Wierz., twenty-eight times; *Plœsoma lynceus* Ehrbg., twenty-six times; *Polyarthra platyptera* Ehrbg., twenty-four times; *Asplanchna priodonta* Gosse, twenty-two times; *Floscularia mutabilis* Bolton, twenty-one times; *Conochilus unicornis* Rousselet, twenty-one times, and *Notommata monopus* Jennings, seventeen times. The others occurred in less than one-third the whole number of towings. As noted below, in the latter part of the summer *Asplanchna Herrickii* de Guerne became very abundant, forming by far the largest number of individuals in the towings during the last weeks of August.

The limnetic rotifers were considerably less abundant in Pine Lake than in the other two lakes. Thus the average number of species occurring in the surface towings from Lake Michigan and from Round Lake was between nine and ten while from Pine Lake the average was but five and a half. In the bottom towings the average for Lake Michigan and Round Lake was five and a half, while for Pine Lake it was four and a half. Some species were not found at all in Pine Lake; this is true of *Conochilus unicornis* Rousselet, which was very common in the other two lakes; also of *Plœsoma Hudsoni* Imh. *Floscularia pelagica* Rousselet occurred but once from Pine Lake; *Plœsoma lynceus* Ehrbg., twice, *Synchæta stylata* Wierz. (very abundant in the other lakes), three times.

During the daylight the limnetic Rotifera are found in much greater numbers near the surface than near the bottom, reversing the condition commonly observed for the Crustacea. This fact is brought out distinctly in the record of towings. In eighteen recorded surface towings from Lake Michigan and Round Lake, taken on different days, the average number of species present was between nine and ten, and the number of individuals of many of these was very great. In twenty recorded towings from near the bottom of the same lakes, the average number of species found was between five and six, and generally but scattered individuals of each species were found—such as might have been caught in pulling the net to the surface. The difference in Pine Lake is not so considerable, since the number of species found there is very small, either at surface or bottom.

At night the distribution seems not to be materially changed. The immense numbers of Crustacea then present near the surface obscure the Rotifera; but no greater number of rotifers was found near the bottom, in the few towings made at night than in the daytime.

My observations tend most distinctly to show that there is great variation in the numbers of rotifers present in any one region within short periods of time; also that there is great variation in the numbers taken in different regions at about the same time. Certain forms seem fairly constant as to their presence in the towings, from the records given above, but these in some of the towings were present in immense numbers, while in other cases only scattered individuals were found. Other species were at one time present in large numbers, at other times entirely lacking, and this within short periods. This fact of great variations in the number and presence of rotifers is so apparent from the towing records that it is difficult to select any special examples. I will record one striking case of variation within twenty-four hours.

Aug. 22, at 2.30 p. m., I towed along the pier projecting into Lake Michigan from the entrance to the harbor of Charlevoix. The towings were made the full length of the pier four times. The material thus obtained contained immense quantities of *Asplanchna Herrickii* de Guerne. Careful examination of the preserved material led to the estimate that about one-fourth of the entire catch consisted of this form.

The next day at 10:30 a. m., I repeated the towings in the same place and with a similar net. The material collected was found to contain very few *Asplanchnas*. Thinking this might be due to some difference in the two nets, I took the same net used the day before, and at the same time of day, 2:30 p. m., I towed along the pier in exactly the same place and in the same way I had done the previous day. Towings were obtained in quantity similar to those of the day before, but they contained almost no specimens of *Asplanchna Herrickii;* after long examination I succeeded in finding a single specimen.

The two days were similar, both bright, with a slight wind, a little stronger on the second day. The direction of the slight current into the harbor was the same both days.

As to variations with the season, only one marked case came under my observation. In June and July, *Asplanchna priodonta* Gosse was one of the commonest limnetic rotifers, while *Asplanchna Herrickii* de Guerne was scarcely ever observed. But in the early part of August the numbers of *Asplanchna Herrickii* greatly increased, so that for a few days about equal numbers of the two species were found. Then the numbers of *Asplanchna priodonta* began to decrease very rapidly while the numbers of the other species continued to increase. In the latter part of August *Asplanchna Herrickii* was by far the most abundant rotifer in the towings, while *Asplanchna priodonta* had almost disappeared.

2. LIST OF ROTATORIA FROM POOLS ON THE SANDY SHORE OF PINE LAKE.

The shore of Pine Lake is in certain parts low, flat and sandy, with numerous very shallow pools, containing a thick growth of the finer algæ, and sometimes of *Utricularia*. Some of these pools are formed by the spreading out of rivulets flowing into the lake; in this case they are generally connected with the lake itself by narrow, shallow streamlets running a short distance over the sand, and containing no vegetation. Other pools are not under ordinary circumstances connected with the lake at all, but lie at the same level as its waters, separated from it by strips of sandy shore. These pools show a fauna differing in character from anything found in the main body of the lake, and a list of the twenty-seven species found is therefore given separately. Eleven of these species were found also in the waters connected with the main body of the three lakes; the rest were not:

Rotatoria from the Pools on the Shore of Pine Lake.

Philodina megalotrocha Ehrbg.
Philodina macrostyla Ehrbg.
Rotifer vulgaris Ehrbg.
Rotifer tardus Ehrbg.
Rotifer trisecatus Weber.
Microcodides orbiculodiscus Thorpe.
Copeus labiatus Gosse.
Furcularia forficula Ehrbg.
Furcularia gracilis Ehrbg.
Furcularia longiseta Ehrbg.
Furcularia micropus Gosse.
Furcularia semisetifera Glasscott.
Mastigocerca bicornis Ehrbg.
Rattulus sulcatus Jennings. (Note 2.)
Dinocharis tetractis Ehrbg.
Polychætus Collinsii Gosse.
Scaridium longicaudatum Ehrbg.
Euchlanis deflexa Gosse.
Euchlanis triquetra Ehrbg.
Monostyla cornuta Ehrbg.
Monostyla bulla Gosse.
Monostyla closterocerca Schmarda (?).
Metopidia lepadella Ehrbg.
Metopidia Ehrenbergii Perty.
Pterodina patina Ehrbg.
Pterodina reflexa Gosse.
Noteus quadricornis Ehrbg.

3. LIST OF ROTATORIA FROM WEST TWIN LAKE.

West Twin Lake is a small inland lake lying at a distance of several miles from the other lakes examined, and connected with Pine Lake only by a small stream. It differs markedly in its main characteristics from the waters directly connected with Lake Michigan. The shores and bottom are of soft deep mud, and vegetation is abundant. Here the rotatorial fauna is much more like that of the shallow parts of Lake St. Clair than was found elsewhere in this region. From this lake the following species were identified.

Rotatoria from West Twin Lake.

Floscularia companulata Dobie.
Floscularia mutabilis Bolton.
Stephanoceros Eichhornii Ehrbg.
Oecistes mucicola Kellicott.
Lacinularia socialis Ehrbg.
Conochilus volvox Ehrbg.
Philodina macrostyla Ehrbg.
Microcodon clavus Ehrbg.
Asplanchnopus myrmeleo Ehrbg.
Ascomorpha hyalina Kellicott.
Anapus ovalis Bergendal.
Synchæta stylata Wierz. (Note 1.)
Polyarthra platyptera Ehrbg.
Notops pygmæus Calman.
Plœsoma lynceus Ehrbg.
Notommata lacinulata Ehrbg.
Notommata monopus Jennings.
Proales laurentinus Jennings. (Note 2.)
Furcularia longiseta Ehrbg.
Diglena grandis Ehrbg.
Mastigocerca bicristata Gosse. (Note 3.)
Mastigocerca capucina Wierz. u. Zach.
Mastigocerca lata Jennings.
Rattulus sulcatus Jennings. (Note 4.)
Dinocharis tetractis Ehrbg.
Euchlanis triquetra Ehrbg.
Euchlanis oropha Gosse.
Cathypna luna Ehrbg.
Distyla signifera n. sp. (Note 5.)
Monostyla bulla Gosse.
Monostyla quadridentata Ehrbg.
Metopidia Ehrenbergii Perty.
Pterodina patina Ehrbg.
Pterodina parva Ternetz.
Pterodina reflexa Gosse.
Brachionus Bakeri Ehrbg.
Brachionus militaris Ehrbg.
Anuræa cochlearis Gosse.

4. LIST OF SOME ROTATORIA IN MATERIAL BROUGHT FROM SUSAN LAKE.

Melicerta ringens Schrank.
Asplanchna Herrickii de Guerne.
Plœsoma lynceus Ehrbg.
Notommata monopus Jennings.
Brachionus militaris Ehrbg.

5. LIST OF ROTATORIA FROM SPHAGNUM SWAMPS NEAR PINE LAKE.

Near the shores of Pine Lake are a number of "tamarack swamps," formed by the spreading out of small streams before entering the lake. These are filled with *Sphagnum* and similar vegetable life, and covered with a dense growth of underbrush and trees, among which the tamarack is predominant. An examination of material brought from these shows that rotifers are not abundant; the forms found are mostly of the families everywhere characteristic of Sphagnum swamps—the *Philodinadœ Cathypnadœ*, and *Coluridœ*. A list of some forms identified is here given:

Rotatoria from Sphagnum Swamps near Pine Lake.

Philodina aculeata Ehrbg.
Callidina constricta Duj.
Callidina magna Plate.
Callidina papillosa Thompson.
Adineta vaga Davis.
Copeus pachyurus Gosse.
Distyla inermis Bryce.
Metopidia solidus Gosse.
Metopidia triptera Ehrbg.

6. LIST OF SPECIES NEW TO THE FAUNA OF MICHIGAN.

In the foregoing lists, containing in all ninety-four species, the following twenty species are recorded for the first time as occurring in Michigan, and so far as I am aware, in America:

Callidina constricta Duj.
Callidina magna Plate.
Callidina papillosa Thompson.
Callidina musculosa Milne.
Adineta vaga Davis.
Asplanchnopus myrmeleo Ehrbg.
Copeus pachyurus Gosse.
Furcularia micropus Gosse.
Furcularia semisetifera Glasscott.
Triophthalmus dorsualis Ehrbg.
Diglena catellina Ehrbg.
Mastigocerca bicristata Gosse.
Cœlopus tenuior Gosse.
Polychætus Collinsii Gosse.
Distyla signifera n. sp.
Distyla inermis Bryce.
Metopidia solidus Gosse.
Pterodina parva Ternetz.
Notholca scapha Gosse.
Notholca foliacea Ehrbg.

7. SYSTEMATIC AND FAUNISTIC NOTES ON CERTAIN SPECIES IN THE PRECEDING LISTS.

(1.) *Synchœta stylata* Wierz.

In my first report on the Rotatoria (Bulletin of the Michigan Fish Commission, No. 3, 1894), I noted the fact that one of the most abundant of the limnetic Rotatoria in Lake St. Clair was *Synchœta stylata* Wierz., while in Whitmore Lake, a small body of water unconnected with the great lakes, *Synchœta pectinata* Ehrbg. was found in equal numbers while *Synchœta stylata* was not present. In the summer of 1894 I hoped to make farther observations on this peculiar difference. In Lake Michigan, Round Lake, and Pine Lake, as was to be expected, only *Synchœta stylata* was found. It seemed possible that in the small inland lake known as West Twin Lake, only indirectly connected with the great lake system, *Synchœta pectinata* would again occur. But such was not the case; *Synchœta stylata* was found in numbers, but no other member of the genus occurred. At the present time, therefore *Synchœta pectinata* has been reported only from Whitmore Lake.

(2.) *Proales laurentinus* Jennings.

This is the form described in Bulletin of the Michigan Fish Commission, No. 3, 1894, as *Notops laurentinus.* The tendency has been in the past few years to consider the genus *Notops* as typically loricate, though belonging to an illoricate family. Of the species described in Hudson and Gosse's Monograph, one is loricate while the other two are not, and the other two genera of this family—*Hydatina* and *Rhinops*—are distinctly illoricate. But *Notops minor* Rousselet, (Journal of the Quekett Microscopical Club, 1892, Series 2, Vol. 4, p. 359), and *Notops pygmæus* Calman, (Annals of Scottish Natural History, Oct. 1892, p. 240), are loricate forms, and show the general tendency to consider this a loricate group. As my species, besides being illoricate, shows undoubted Notommatoid characteristics in other respects, as was noted in my description, it should probably be transferred to another genus. Mr. Charles Rousselet, of London, England has recently discovered on Hertford Heath a species very similar to this, but of a more slender form, showing still farther the relationship with the *Notommatadæ.* His species could not possibly be considered a *Notops,* and as the two undoubtedly belong together I have adopted the suggestion of Mr. Rousselet that both should be referred to the rather heterogeneous and ill defined genus *Proales.*

(3.) *Mastigocerca bicristata* Gosse.

This is not the form mentioned on page 19 of my report in Bulletin of the Michigan Fish Commission No. 3, 1894, but is evidently the real *Mastigocerca bicristata* of Gosse, while the form there mentioned is a new species. It agrees with *Mastigocerca bicristata* Gosse in having two crests, but differs markedly in other respects. Only a few specimens of the real *Mastigocerca bicristata* were found amid *Utricularia* from West Twin Lake. The other two-crested species was very abundant, especially in Round Lake and in the channel between Round Lake and Pine Lake. It is hoped some time in the future to publish careful comparative descriptions of the two forms; at present my notes and figures are not complete.

(4.) *Rattulus sulcatus* Jennings.

This form was described and figured by Bilfinger, in a paper which came just too late to be mentioned in my previous report (l. c.), as *Cœlopus brachiurus* Gosse (?). (Bilfinger *Zur Rotatorienfauna Württembergs,* *Zweiter Beitrag*, Jahreshefte des Vereins für vaterl. Naturkunde in Württemberg, 1894.) As Bilfinger states, the animal is unquestionably a *Rattulus* and not a *Cœlopus*. I have seen the two equal toes widely separated, then closed together again. Furthermore the toes are here very short (0.022 mm.) both relatively and absolutely, forming only about one-seventh of the entire length of the animal (0.144 mm.). I give Bilfinger's measurements, as they agree almost exactly with my own. But in *Cœlopus brachiurus* as described and figured by Gosse, the toes are both relatively and absolutely much longer ($\frac{1}{580}$ inch = .043 mm.), forming about one-fourth of the entire length of the animal. Mr. Charles Rousselet has been so good as to send me some farther notes and figure of *Cœlopus brachiurus* Gosse, as found in England, and from these the distinctness of the two forms seem still more clear. *Cœlopus brachiurus* swims commonly with the toes held straight out behind, according to Mr. Rousselet, whereas in the many living specimens of this *Rattulus* which I have seen, the toes are always retracted, as shown in my own figures and that of Bilfinger. Bilfinger states also that in all specimens seen by him the toes were retracted. In *Cœlopus brachiurus*, even when the toes are "thrust up under the belly," as figured by Gosse in the monograph, they are not held at all in the same position as in *Rattulus sulcatus*, being turned points forward instead of being retracted into the lorica in their natural position.

The following then are the points of difference:

Cœlopus brachiurus **Gosse.**	***Rattulus sulcatus*** **Jennings.**
Toes of the *Cœlopus* type (?).	Toes equal and side by side (*Rattulus* type).
Length of toes, $\frac{1}{580}$ inch=.043 mm.	Length of toes, .022 mm.
Total length, $\frac{1}{135}$ inch=.185 mm.	Total length, .144 mm.
Toes nearly ¼ of entire length.	Toes about $\frac{1}{7}$ of entire length.
Toes held straight out behind or curved, points forward.	Toes retracted within the lorica.

It seems to me beyond question that the two forms are distinct.

Mr. Rousselet suggested the possibility of the identity of this form with *Cœlopus porcellus* Gosse, and sent me mounted specimens of that form for comparison. The distinction is at once evident on comparing the two animals; moreover, *Cœlopus porcellus* is common in Michigan. I was acquainted with it before I saw this Rattulus.

Rattulus sulcatus it seems to me then is certainly a species distinct from any hitherto described.

(5.) *Distyla signifera* n. sp.

Lorica of the flattened truncate elliptical form typical of the genus: the whole animal in general form much like the *Distyla inermis* of Bryce (Science Gossip, Dec., 1892), though perhaps a little broader. But the *lorica is marked both dorsally and ventrally by crescentic elevations*, arranged in somewhat regular patterns. On the ventral surface these are mostly in longitudinal rows, while on the dorsal surface the pattern is considerably more complicated and at the same time less regular. The two figures, from camera drawings, render a minute description of the arrangement of these elevations superfluous. The dorsal view shows not only the arrangement but also, so far as possible, the size and form of each of the markings; in the ventral view the arrangement is accurate, but each elevation was not outlined separately with the camera. The toes are rod-like, tapering near the distal end on the *outer* side, so as to form an inner

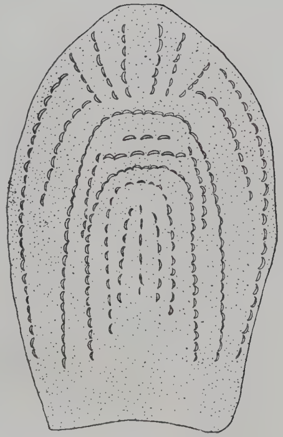

FIG. 2.

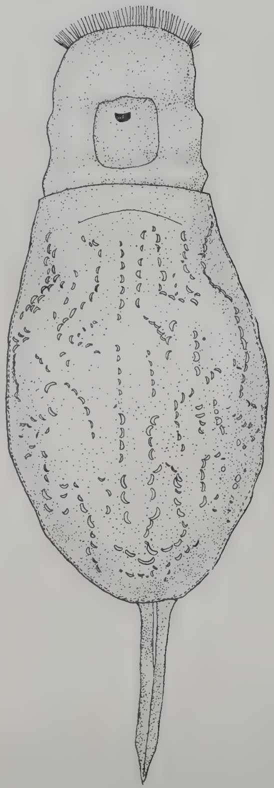

FIG. 1.

point—so that when the two toes are placed side by side only one point is formed. The internal anatomy offers nothing of interest.

All distinctive characters of the animal are better indicated by the figures than would be possible by an extended description.

Length, about .22 mm.

In Utricularia from West Twin Lake; not common.

Figure 1.—Dorsal view of the entire animal.

Figure 2.—Ventral view of the lorica.

(6.) *Monostyla lunaris* Ehrbg.

This common form agrees with descriptions and figures of *Monostyla lunaris* Ehrbg., except that the toe is *not protruded between two spines*, but the foot passes without break into the toe. The foot is *unjointed*, so that this is not the *Monostyla Quennerstedtii* of Bergendal. I have not considered this variation to be of sufficient importance to separate my form from the common one.

APPENDIX IV.

PRELIMINARY REPORT ON COLLECTIONS OF TURBELLARIA FROM LAKE ST. CLAIR AND CHARLEVOIX, MICHIGAN.[1]

BY W. McM. WOODWORTH, INSTRUCTOR IN MICROSCOPICAL ANATOMY, AND MUSEUM ASSISTANT IN CHARGE OF VERMES, HARVARD UNIVERSITY.

A more detailed report with figures will appear in the Bulletin of the Museum of Comparative Zoölogy.

The collections, though small, contribute three new species to the Turbellarian fauna of the United States, two of which have never before been described. In the absence of any data regarding the color and shape of the living animals, the descriptions are necessarily based upon the appearances of the alcoholic material.

Planaria simplex sp. nov.

One Specimen. "Dredge Aug. 11, 1894, off N. Y. Point, Lake Michigan." Length 4 mm., greatest breadth 1.8 mm. General shape ovate. Broadest at $\frac{1}{5}$ the total length from the anterior end, tapering from here to rounded posterior extremity. Anterior end rounded, set off from rest of body by slight lateral indentations at the level of the eyes, i. e., about $\frac{1}{10}$ the total length from anterior end. Broadest diameter $\frac{1}{5}$ the distance from anterior end. No cephalic appendages. Mouth $\frac{1}{3}$ total length from posterior end. Eye spots elongated, crescentic, facing outward and forward at an angle of 45° to the chief axis of the worm. Intestine of the simple triclad type. No signs of sexual organs. Immature. Pigment, located in spots of nearly uniform size, distributed uniformly over all parts of the body; no clear areas at sides of head nor surrounding the eyes. Color of alcoholic specimen ochre yellow.

Planaria maculata Leidy.

One specimen from New Baltimore, Lake St. Clair, Aug. 20, 1893. Seven specimens "on leaves of Nymphea, Twin lakes, Charlevoix, Aug. 6, 1894." Four specimens from "Utricularia-washings, West Twin Lake, Charlevoix, Aug. 13, 1894."

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[1] Contributions from the Zoölogical Laboratory of the Museum of Comparative Zoölogy, E. L. Mark, director, No. LXIII.

* **Procotyla fluviatilis** Leidy.

"Round Lake July 9, 1894." Probably the above species. Catalogued as "white planarian." No other data.

Mesostoma Wardii sp. nov.

Nine specimens: "Turbellaria [from] algæ, Aug. 20, 1893, New Baltimore," Lake St. Clair. Length 2–3 mm., greatest breadth 1–1.4 mm. Very thin and flat. Anterior end tapering, rounded, marked off from body by a slight constriction. Posterior end tapering sharply and terminating in an acute caudal process. Pharynx large, prominent, in middle third of body. Specimens mostly immature; nothing definite could be determined regarding the sexual organs. Color of alcoholic material yellowish; very translucent.

Mesostoma viridatum M. Sch.

Seven specimens from "Utricularia-washings, West Twin Lake, Charlevoix, Aug. 13, 1894." A cosmopolitan form, but new to the United States.

* **Mesostoma viviparum** Silliman.

"Old channel, Round Lake, Charlevoix, on algæ, July 13, 1894."

* **Vortex armiger** O. Schm.

New Baltimore, Lake St. Clair, Aug. 6, 1893.

* **Vortex** sp.?

"Round Lake, Charlevoix, dredgings from old channel July 20, 1894. Length 0.96 mm., breadth 0.24–0.32 mm. Anterior end truncated posterior end pointed. Pharynx dolioform, in anterior $\frac{1}{3}$ of body, traversed by two prominent, lateral, nearly longitudinal bands of light chocolate color. Zoöchlorellæ in central part of body."

Microstoma lineare Oers.

One broken stock from "Utricularia-washings, West Twin Lake, Charlevoix, Aug. 13, 1894."

*"Old channel, Round Lake, Charlevoix, July 13, 1894, in chains of 2 to 4."

* **Microstoma variabile** Leidy.

"Algæ culture, shore, Charlevoix, July 24, 1894. One specimen: chain of four individuals."

Microstoma caudatum Leidy.

Two specimens from "Utricularia-washings, West Twin Lake, Charlevoix, Aug. 13, 1894." Both stocks consisting of two individuals.

Museum of Comparative Zoölogy,
Cambridge, Mass., Jan. 31, 1896.

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*The species marked with an asterisk were not sent to me. The accounts given here are from notes and drawings by Prof. H. B. Ward.

APPENDIX V.

REPORT UPON THE MOLLUSCA COLLECTED IN THE VICINITY OF CHARLEVOIX, MICHIGAN, IN THE SUMMER OF 1894.

BY BRYANT WALKER, DETROIT, MICH.

The molluscan fauna of Charlevoix, is that common to the northern portion of the lower peninsula, and seems to possess but little that is purely local in its nature. As a whole, however, it is distinctly northern in its character, as compared with that of the southern part of the state. In the terrestrial species this is shown in the occurrence of *Vitrina* and numerous species of Zonitidæ and Endodontidæ, to the almost entire exclusion of the larger species of Helicidæ, which abound further south. While in the aquatic forms, the Limnæidæ, Physidæ, and Corbiculidæ, all of which are peculiarly northern in their distribution, form nearly three-fourths of the entire number of species.

The number of species of terrestrial mollusca collected was not as great as might reasonably have been expected. This was probably in part due to the sandy nature of the soil, which prevails all along the eastern shore of Lake Michigan, and partly to the excessive drought which then prevailed. Of the thirty-one species collected, two—*Pyramidula asteriscus* Mse., and *Strobilops virgo* Pils.—are interesting additions to the fauna of the state.

The number of fluviatile species collected was sixty-four, of these thirty-seven were univalves and twenty-seven were bivalves.

The following is a summary of the families represented:

Pulmonata	Limnæidæ	22	
	Physidæ	4	
			26
Prosobranchiata	Valvatidæ	2	
	Viviparidæ	3	
	Rissoidæ	4	
	Pleuroceridæ	2	
			11
Pelecypoda	Unionidæ	9	
	Corbiculidæ	18	
			27

The most striking feature of this fauna is the large number of species belonging to the Corbiculidæ. Of the nineteen species recognized, no less than ten are new to the fauna of the State, and of these, one (*Pisidium milium* Held.) is a European species not before found in this country, and seven (*Sphœrium* 1, *Pisidium* 6) are probably new to science.

Other interesting discoveries were a small and very fragile deep-water form of *Limnœa stagnalis* L. and very small globose *Limnœa*, which may prove to be a new form, at High Island Harbor in the Beaver islands; a new fossil *Limnœa* from the marl deposits in Pine Lake at Charlevoix, and the recently described *Planorbis bicarinatus Aroostookensis* Pils. and *P. exacutus rubellus* Sterki from small ponds in the same vicinity.

The fauna of Lake Michigan does not seem to differ materially from that of the neighboring inland lakes. The apparent scarcity of the larger bivalves (*Unio*, *Anodonta* and *Margaritina*) shown in the present collection may possibly be explained by the unfavorable conditions which prevail in the immediate neighborhood of Charlevoix, owing to the exposed coast and rocky bottom in that vicinity. Further and more extended observations will be necessary before such a deduction can be made with any degree of certainty.

This fact, if it be one, does not, however, play any considerable part in the economic features of the fauna which more particularly concern the special line of investigation carried on by the Commission.

It is not probable, owing to their large size and heavy shells, that the Unionidæ afford any considerable amount of fish food. In the earlier stages of development, while yet small they no doubt are eaten to some extent.

There is no question, however, but that the smaller species which are to be found in great quantities in suitable localities, constitute an important item in the food supply of those species of lake fish, such as the whitefish, sturgeon, etc., which are bottom feeders. The forms thus utilized, would include among the univalves most of the species belonging to the following genera: *Limnœa, Physa, Planorbis, Segmentina, Valvata, Amnicola* and *Bythinella* and among the bivalves, the numerous species of *Sphœrium* and *Pisidium.*

The following genera were found in the stomachs of whitefish collected this last season:

Amnicola, Valvata, Sphœrium, Pisidium, Limnœa, Physa, Planorbis.

The great abundance of these small mollusks under favorable conditions was well shown at High Island, where a single haul of the trawl over a thick growth of *Chara* brought to surface several hundred specimens of twenty-six species belonging to the following genera:

Limnœa	5
Planorbis	3
Physa	1
Valvata	2
Amnicola	3
Bythinella	1
Pisidium	11

Not only are these forms exceedingly abundant, but their bathymetric range is also very considerable. Thus *Limnœa, Planorbis, Valvata, Amnicola, Sphœrium* and *Pisidium* were found living at a depth of twenty-five metres. Although, in the few instances in which the dredge was lowered to a greater depth, no mollusca were obtained, this result can scarcely be considered as determinative in this particular. It seems probable, however, that the *Pisidia* range to a much greater depth than the other genera.

(See Rep. U. S. Fish Com. 1872–3, page 707).

As in other forms of animals, the abundance of molluscan life is dependent upon a favorable environment and ample supply of food. All of the univalves species found in the great lakes are vegetable feeders, while the bivalves live upon the minute organisms (algæ) which they find floating in the water. An abundant vegetation therefore is a prime requisite for any extensive development of a molluscan fauna.

This interdependence of the various forms of life was very strikingly illustrated in the fauna of the various inland lakes in the vicinity of Charlevoix. Thus in Pine Lake where, owing to the character of the bottom which is almost wholly composed of a fine disintegrated marl, except in places where a thin coating of sand has been washed in from the shore, plant life is very meagre and stunted in its growth, there was a marked scarcity in the mollusca, not only in the number of species, but in their individual abundance. While in other lakes when the conditions were favorable for a luxuriant vegetation, there was a corresponding increase in the higher forms of life.

The following is a complete list of the species collected:

	Land.	Lake Michigan.	Inland waters.
Limax campestris Binn.	X	-------	-------
Vitrina limpida Gld.	X	-------	-------
Gastrodonta nitidus Mull.	X	-------	-------
Vitrea arboreus Say.	X	-------	-------
radiatulus Alder	X	-------	-------
indentatus Say.	X	-------	-------
Binneyanus Mse.	X	-------	-------
ferreus Mse.	X	-------	-------
exiguus Stimp.	X	-------	-------
Conulus fulvus Dr.	X	-------	-------
Tebennophorus Carolinensis Bosc.	X	-------	-------
Pyramidula alternata Say.	X	-------	-------
alternata alba.	X	-------	-------
striatella Anth.	X	-------	-------
asteriscus Mse.	X	-------	-------
lineata Say.	X	-------	-------
Polygyra albolabris Say.	X	-------	-------
Sayi Binn.	X	-------	-------
monodon Rack.	X	-------	-------
Strobilops labyrinthica Say.	X	-------	-------
virgo Pils.	X	-------	-------
Acanthinula harpa Say.	X	-------	-------
Pupa contracta Say.	X	-------	-------
Vertigo ovata Say.	X	-------	-------
Bollesiana Mse.	X	-------	-------
ventricosa elatior Sterki	X	-------	-------
pentodon Say.	X	-------	-------
Ferussacia subcylindrica L.	X	-------	-------
Succinea avara Say	X	-------	-------
obliqua Say.	X	-------	-------
ovalis Gld. var.	X	-------	-------
Carychium exiguum Say.	X	-------	-------
Limnœa stagnalis L.	-------	-------	X
stagnalis L. var.	-------	X	-------
ampla Migh.	-------	-------	X
emarginata Say.	-------	X	-------
catascopium Say.	-------	X	X
reflexa Say.	-------	-------	X
lanceata Gld.?	-------	X	-------

	Land.	Lake Michigan.	Inland waters.
Limnœa pallida Ads.? (fossil)			X
galbana Say. (fossil)			X
desidiosa Say		X	X
humilis Say			X
sp.		X	
sp. (fossil)			X
Physa ancillaria Say.		X	X
gyrina Say.		X	X
heterostropha Say.			X
integra Hald.		X	X
Planorbis trivolvis Say.			X
bicarinatus Say.		X	X
bicarinatus Aroostookensis Pils.			X
campanulatus Say.			X
multivolvis Case.			X
exacutus Say.		X	
exacutus rubellus Sterki.			X
albus Mull.			X
parvus Say.		X	X
deflectus Say.			X
Segmentina armigera Say.			X
Ancylus parallelus Hald.			X
Valvata tricarinata Say.		X	X
tricarinata bicarinata Lea.		X	
sincera Say.		X	
Campeloma decisa Say.		X	X
integra Say.			X
Milesii Lea.			X
Amnicola limosa Say.		X	X
lustrica Pils.		X	X
grana Say.		X	
porata		X	X
Bythinella obtusa Lea.		X	
Pleurocera subulare Lea.			X
Goniobasis livescens Mke.		X	X
Unio luteolus Lam.			X
borealis Gray.			X
Margaritina rugosa Bar.			X
Anodonta edentula Say.			X
fragilis Lam.			X
Footiana Lea.		X	
Marryatana Lea.			X
Ferussaciana Lea.		X	
subcylindracea Lea.		X	X
Sphœrium simile Say.		X	X
striatinum Lam.		X	X
rhomboideum Say.			X
rosaceum Pme.			X
sp.		X	
Pisidium Idahoense Roper.		X	
variabile Pme.		X	X
abditum Hald.		X	X
compressum Pme.		X	X
ventricosum Pme.		X	X
punctatum Sterki.		X	
sp.		X	X
sp.		X	X
sp.		X	X
trapezoideum Sterki, mss.		X	X
sp.		X	
sp.		X	
milium Held.			X

ERRATA.

Page 3, line 13, for " Reighard, 95," read " Reighard, 94".
Page 8, footnote, line 2, for " p. 250 " read " p. 259".
Page 11, second line from bottom, for " p. —" read " p. 72".
Page 12, line 24, for " p. —" read " p. 76".
Page 12, line 28, for " Ryder (81)" read " Ryder (84)".
Page 16, line 7, after " species " insert " of insects".
Page 17, sixth line from bottom, for " Reighard (95)" read " Reighard (94)".
Page 19, line 15, for " Forbes (82)" read " Forbes (83)".
Page 21, line 11 of table, for " *lustuca* " read " *lustrica* ".
Page 21, line 15 of table, for " Lan." read " Lam."
Page 27, line 26, for " depedent " read " dependent ".
Page 28, second footnote in third and in last lines, for " *Melonia* " read " *Melosira*".
Page 36, last line above table omit the word " total ".
Page 37, line 20, for " afford " read " affords ".
Page 38, second table in first line, for " 10.7 " read "10.0," and for " 3.6 " read " 4. 3 ".
Page 38, second table in last line, for " 19.5118 " read " 19.4937"
Page 38, last line, for " 3.5 per cent " read " 4 per cent".
Page 43, last table in last column, for " 3.98 " read " 3.97".
Page 45, line 24, for " agreed " read " agrees".
Page 55, line 8, for " Clain " read " Clair".
Page 55, line 34, for " Reighard (93)," read "(94)".

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PLATE I.

TABULAR VIEW OF BOTTOM HAULS WITH VERTICAL NET.

A, IN LAKE MICHIGAN.

B, IN ROUND AND PINE LAKES.

Vertical lines indicate stations, each of which is designated by a Roman numeral at the upper end.

Horizontal lines denote distance or amount as shown at the margin.

D--------D. Indicates depth of various stations.

T--------T. Shows total volume of plankton in bottom hauls with vertical net.

R--------R. Shows the estimated volume of plankton per cubic meter of water in the same hauls.

? Denotes a doubtful observation.

For further details see text.

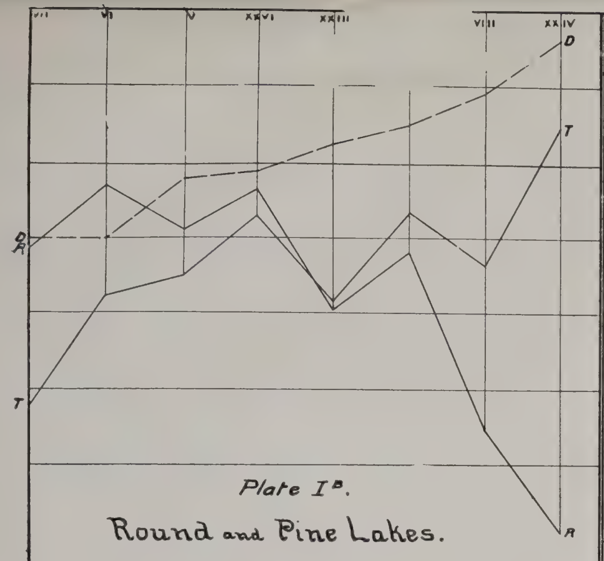


Plate I^B.

Round and Pine Lakes.

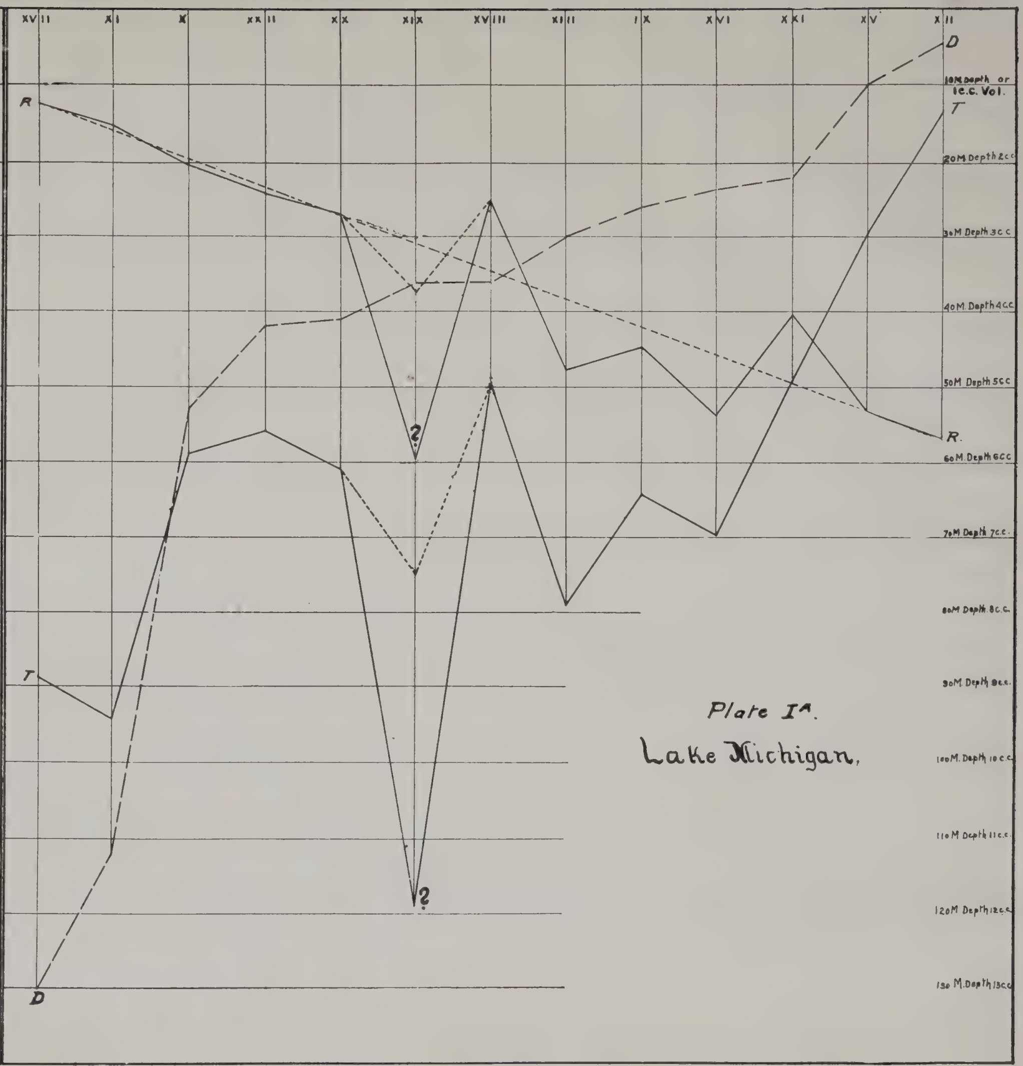


Plate I^A.

Lake Michigan.

PLATE II.

TABULAR VIEW OF STRATAL HAULS WITH VERTICAL NET.

A, IN LAKE MICHIGAN.

B, IN ROUND AND PINE LAKES.

Vertical lines indicate stations, and horizontal lines amount of plankton obtained

D--------D. Indicates the depth of various stations.

S--------S. Shows the amount of plankton per cubic meter of water in hauls from 2m. to surface.

2–5m., the same in hauls from 5m.–2m.

5–10m., " " " " " 10m.–5m.

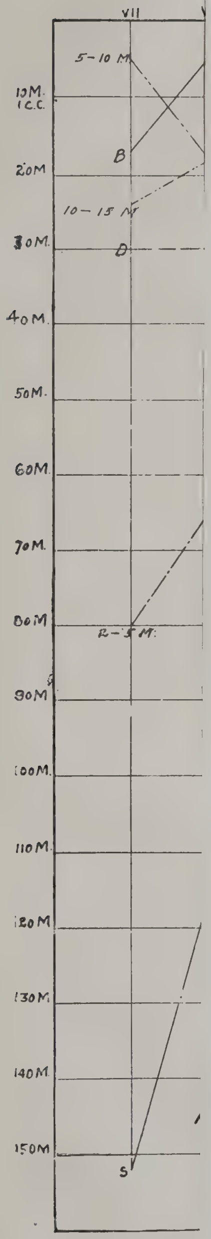
10–25m., " " " " " 25m.–10m.

25–50m., " " " " " 25m.–50m.

50m.–bottom, the same in hauls from bottom to 50m.

? Denotes a doubtful record or observation.

Further details in text.


VII
5-10 M
10M.
1 C.C.
B
20M
10-15 M
30M.
D
40M.
50M.
60M.
70M.
80M
2-5 M.
90M
100M.
110M.
120M
130M
140M
150M
S

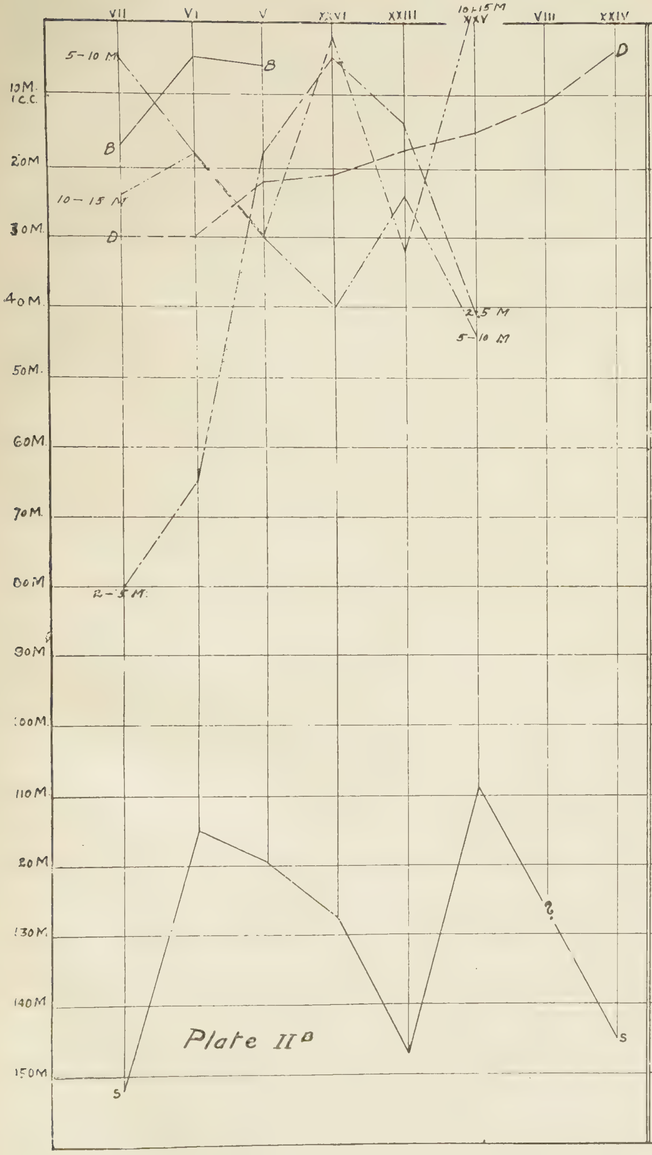


Plate II^B

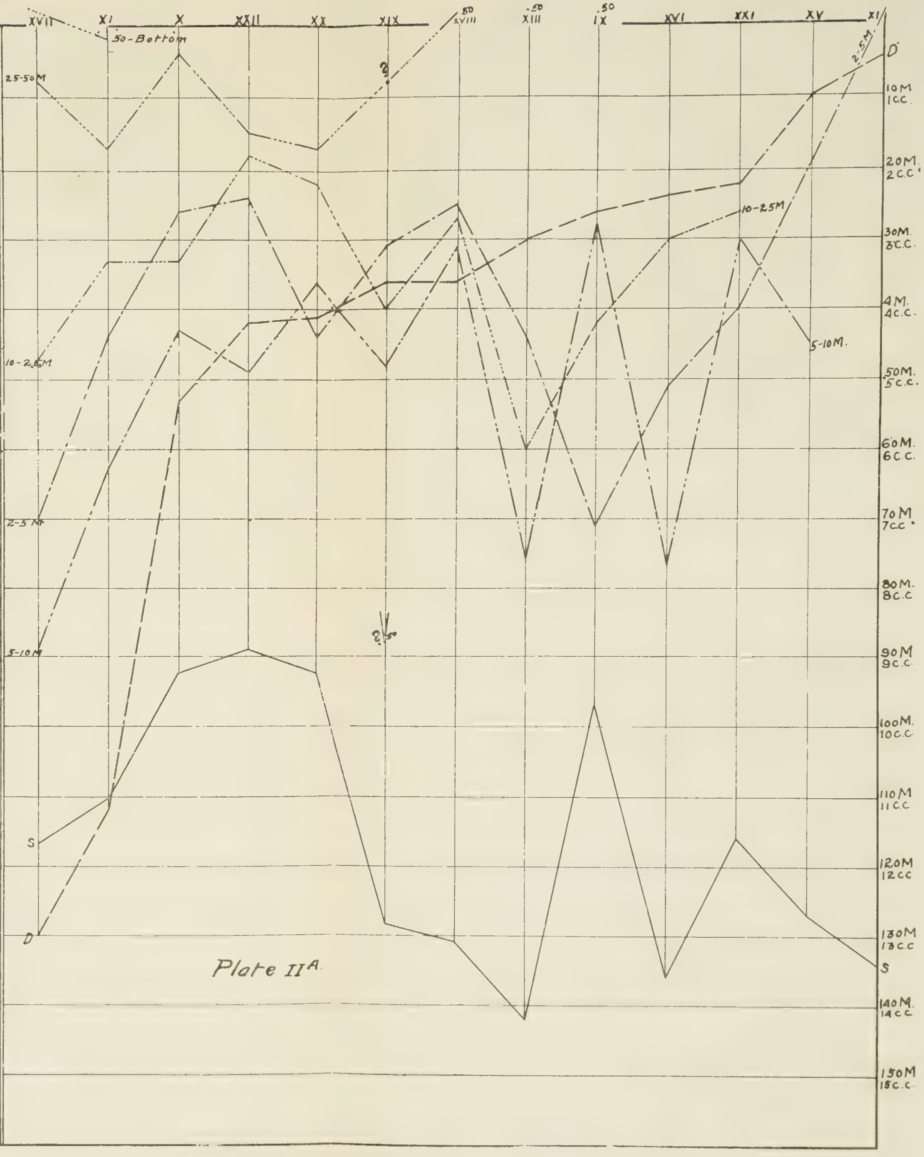


Plate II^A

PLATE III.

Tabular View of Plankton Hauls in Lake St. Clair. These Were Plotted from Results Given by Reighard, 94, p. 35.

Stations are indicated by vertical lines; distances or amounts by horizontal lines.

D--------D. Indicates the depth of the various stations.

T--------T. Shows the total amount of plankton obtained in bottom hauls.

R--------R. The amount of plankton per cubic meter of water for the same hauls.

S--------S. The amount of plankton per cubic meter of water contained in the surface 1.5m.

1.5–4.5m. The amount of plankton per cubic meter of water in the stratum 4.5m. to 1.5m., or bottom to 1.5m. if shallower.

B--------B. The amount of plankton per cubic meter of water in the stratum from bottom to 4.5m.

For discussion and explanation see text.

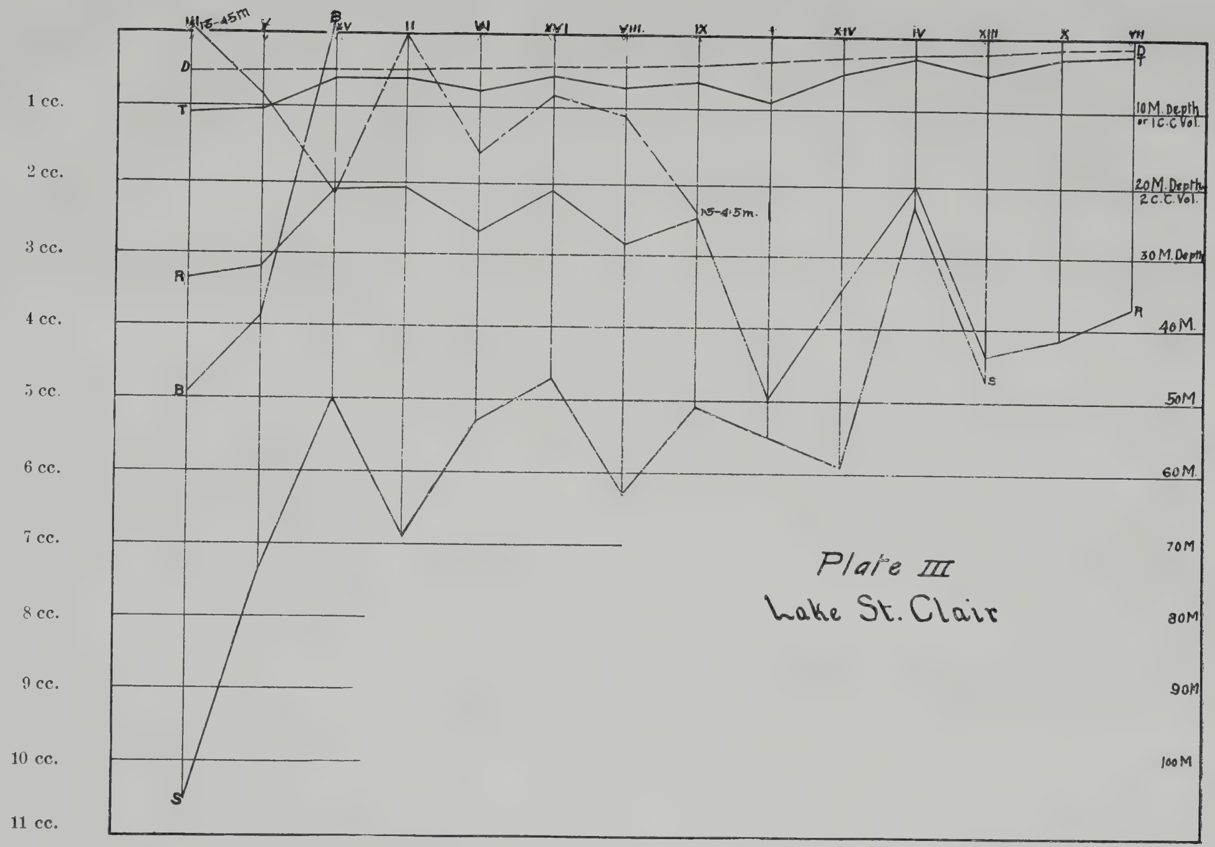


Plate III
Lake St. Clair

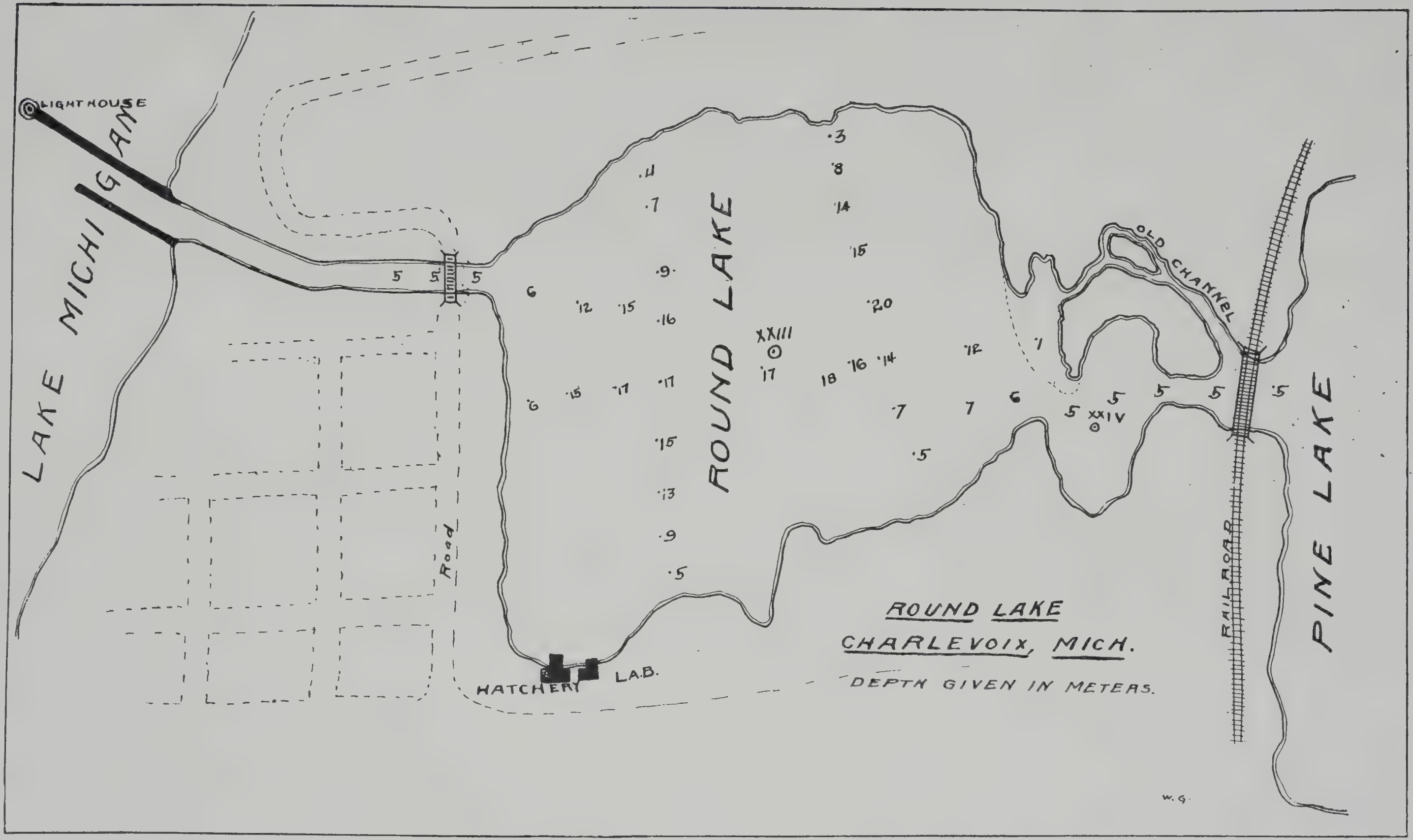
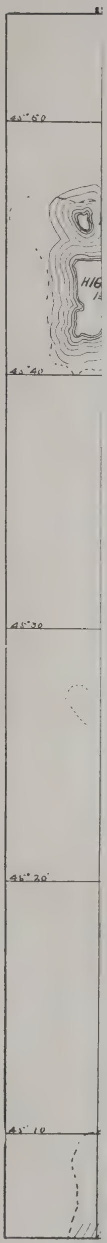

LIGHTHOUSE
LAKE MICHIGAN
ROUND LAKE
OLD CHANNEL
RAILROAD
PINE LAKE
XXIII
XXIV
Road
HATCHERY
LAB.
ROUND LAKE
CHARLEVOIX, MICH.
DEPTH GIVEN IN METERS.
W. G.

PLATE IV.


45°50
HIG
1
45°40
45°30
45°20
45°10

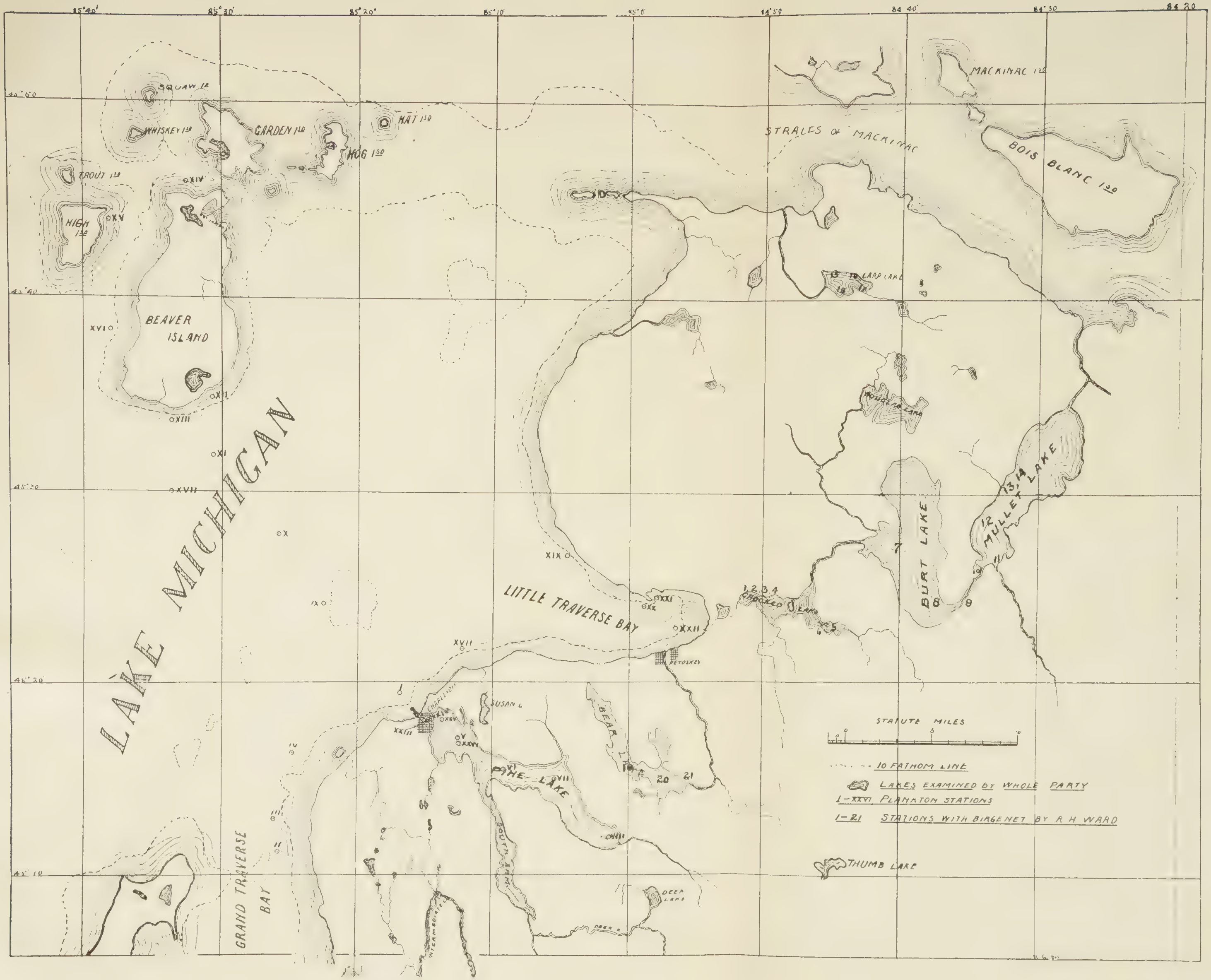
85°40'
85°30'
85°20'
85°10'
85°0'
84°50'
84°40'
84°30'
84°20'
45°50'
45°40'
45°30'
45°20'
45°10'
SQUAW I^D
WHISKEY I^D
GARDEN I^D
HOG I^D
HAT I^D
TROUT I^D
HIGH I^D
BEAVER ISLAND
MACKINAC I^D
STRAITS OF MACKINAC
BOIS BLANC I^D
CARP LAKE
DOUGLAS LAKE
BURT LAKE
MULLET LAKE
CROOKED LAKE
LAKE MICHIGAN
LITTLE TRAVERSE BAY
PETOSKEY
CHARLEVOIX
SUSAN L
BEAR L
PINE LAKE
SOUTH ARM
INTERMEDIATE L
DEER LAKE
GRAND TRAVERSE BAY
STATUTE MILES
0
5
10
10 FATHOM LINE
LAKES EXAMINED BY WHOLE PARTY
1–XXVI PLANKTON STATIONS
1–21 STATIONS WITH BIRGE NET BY R H WARD
THUMB LAKE

PLATE V.

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